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BULLETIN OF THE TORREY BOTANICAL CLUB
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GLANDULAR LEAF HAIRS OF ORIENTAL TOBACCO[1]

NANCY J. BENTLEY AND F. A. WOLF

INTRODUCTION

Numerous studies of plant hairs or trichomes have been made. Interest in these structures in the past appears to have remained largely academic, although certain studies that deal with cotton constitute a notable exception. Be that as it may, the studies which are summarized in a monograph by Netolitzky (1932) have yielded a body of knowledge concerning the origin, structure, classification, physiology, and ecology of trichomes. It is strikingly apparent from perusal of this monograph, moreover, that certain investigators have emphasized structural differences as bases for classifying trichomes whereas others have laid stress upon functional differences.

Seemingly trichomes have been variously defined and delimited in botanical writings, but the term is generally understood to apply to *epidermal* outgrowths that are external to and may occur upon any of the above-ground parts of ferns (Pteridophyta) and seed plants (Spermatophyta). Plants that belong in other phyla and which, therefore, are not properly regarded as possessing an *epidermis* may not, in accordance with restrictions imposed by this interpretation, be said to have trichomes. According to this concept of the term, moreover, such hairs as may occur within the intercellular spaces of certain aquatic plants, as among certain Araceae and Nymphaeaceae, or as the elements projecting from the inner locule walls of young *Citrus* fruits, which give rise to the pulp sacks, and the root hairs of seed plants generally, are not properly designated as trichomes.

As defined by Weiss, in 1867 (Netolitzky 1932), "A plant hair is a direct prolongation of an epidermal cell; it arises *externally*,[2] is thread-like, branched or unbranched, and consists of one or more similar or dissimilar cells." As characterized by de Bary (Netolitzky 1932), ten years later, trichomes are projections from and extensions of the upper wall of epidermal cells from which they have their origin. In the concept of Netolitzky

[1] These researches and those upon which a previous report was based were subsidized in part by the General Education Board. The previous report (Wolf and Jones 1944) dealt with the structure of green leaves of oriental varieties of tobacco at different stalk positions in relation to quality of cured leaves.

The constructive criticism of Drs. P. M. Gross and F. R. Darkis is gratefully acknowledged.

[2] Netolitzky (1. c., p. 7, 147) points out that part of the "druse" hairs of *Pogostemon* (Labiatae) extend outward and others inward, and therefore that it seems absurd not to regard both structures as hairs. (Some might be inclined to question the use of the term druse to apply to glandular hairs.)

(1932), more emphasis should be placed upon function than upon structure, for he states that trichomes are *epidermal organs*, i.e., *not mere appendages*, of characteristic structure that aid or enhance the epidermis better to function in protection, absorption, secretion, or storage, or to serve as sense organs.

Species of *Nicotiana* and of such closely related genera as *Solanum*, *Petunia*, *Physalis*, and *Lycopersicum* have long been known to possess both glandular and non-glandular hairs. It appears that the use made by these plants of their own glandular-hair secretions is quite unknown. On the other hand evidence was presented in a recent report (Wolf and Jones 1944) indicating that the characteristic aroma of tobacco is traceable primarily to the resinous exudate from glandular hairs. Since aromas of oriental tobaccos are their most prized attributes, a knowledge of glandular hairs becomes of enhanced interest, especially to tobacconists and botanists. The purpose of the present report therefore is to contribute further observations relating to glandular hairs on *Nicotiana*, and, so far as seems warranted, to interpret these observations.

MATERIALS AND METHODS

In these studies both natural and artificial environments in which to grow plants were employed. Under the former conditions twenty-nine varieties and strains of oriental tobacco were grown in a field at the Tobacco Experiment Station, Oxford, N. C., during the 1944 season, and, under the latter, four varieties were grown under glass, at Durham, N. C., during the preceding winter and spring.

Seedlings of the varieties grown under glass were transplanted into a sandy loam soil placed in 4-inch, unglazed, earthenware pots. Here they grew slowly, and all the leaves, as they matured, beginning with the lowermost, were removed from analysis. The period of their removal extended over the interval February 14 to May 12. It became necessary to limit to six the number of plants analyzed in each of the four varieties because the making of analyses was so time-consuming.

Seedlings of all varieties grown in the field were transplanted during the second week of May. They were spaced 5½ inches apart in 20-inch rows. Fertilization and cultivation of the kind and amount best suited to them, as indicated by previous experience in the culture of oriental tobacco, were given these plants. Harvesting began early in July and terminated two months later.

Preliminary sampling indicated that the total hair population of each leaf on any plant grown outdoors, regardless of its level on the stalk, is quite the same, except for a few of the uppermost leaves. For this reason it was deemed satisfactory to select five representative plants of each variety

and to take, for the analyses, three leaves from the median region of each such selected plant. In varieties that exhibited small differences in hairiness between these five selected plants the number of plants analyzed was limited to five. If, however, the differences between plants were rather large, more than five plants, the number being determined by available time, were analyzed in a search for individuals with leaves having a greater than average hair population.

Results of the analyses, upon which this report is based, involved the use of more than 2000 leaves on each of which the hair population in ten places was counted. To do this the lower epidermis was stripped off for microscopic examination. Large strips of lower epidermis may be removed with facility if the leaf is held taut over a finger tip and torn toward the midrib or toward the base of the leaf. It is quite impossible, however, by the same technique, to strip off large pieces of the upper epidermis because the palisade parenchyma adheres so closely.

Five ample strips of the lower epidermis of each leaf examined were placed in a film of water on a microscopic slide with the outer leaf surface uppermost. A cover glass was not applied for the reason that if the hairs are permitted to stand erect they can readily be brought into focus for counting. The hairs in two arbitrarily chosen microscopic fields on each strip were counted, and the average of these ten counts was taken as the number of hairs per unit area of leaf surface. The determination of hairiness and of leaf area of the tobacco varieties therefore rested upon two measurements: (1) an average of ten direct counts of hairs under low power magnification, using such combination of lenses that the area of the microscopic field was 1.0936 mm.^{2}; and (2) a computed determination of leaf size. The size of a leaf was determined by tracing it to make a paper pattern which was, in turn, weighed and compared with the weight of a standard made from the same kind of paper. The weight per unit area of the standard had previously been determined. From the figure representing the number of hairs per mm.^{2} on the lower leaf surface and the figure representing the calculated leaf area, the hair population per leaf was derived.

Hairiness, as used throughout this report, applies to the hair population on the lower leaf surface only. It was found possible, however, to determine hair population on both the upper and lower leaf surface of one and the same leaf. To do this leaf fragments were dehydrated by passage through graded concentrations of ethyl alcohol, after which they were cleared in methyl salicylate. When this was done the number of hairs per unit area on each surface, first on one side of the leaf fragment, then on the other, could be determined. By this technique it was found that the number of hairs on the upper leaf surface is approximately 20–25 per cent greater than on the lower surface.

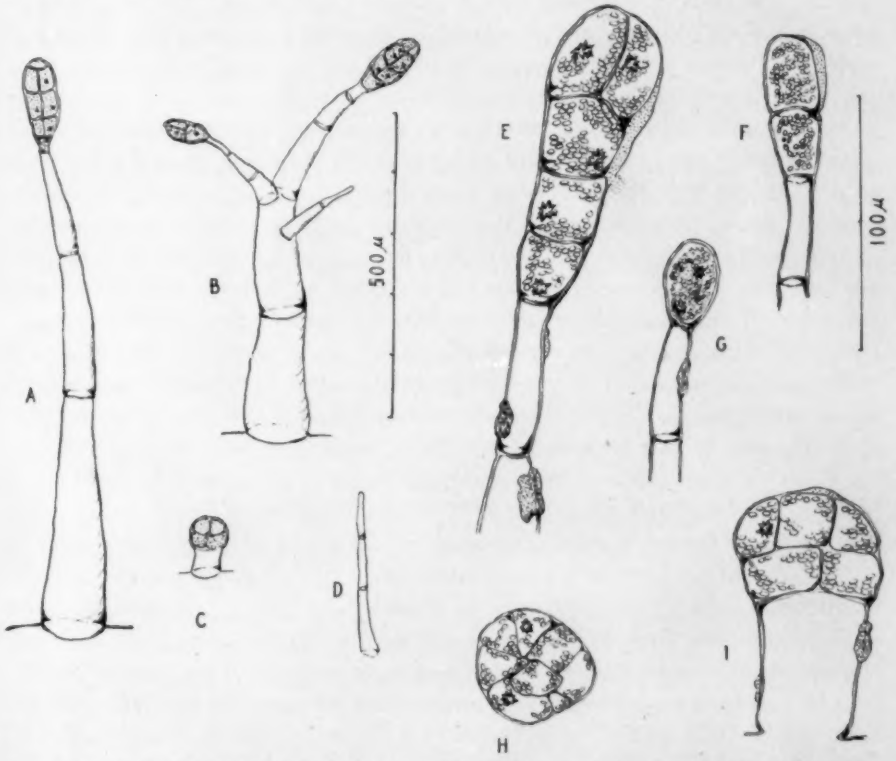
It is recognized that these methods of analyses permit errors of appreciable magnitude to be made, an eventuality that appears unavoidable for the following reasons: (1) Glandular hairs are not uniformly distributed over the leaf surface. Their distribution appears to follow the pattern of leaf expansion, as described by Avery (1933) in studies of growth of tobacco leaves. The hair population tends to be densest in areas of least expansion. Then of course, it becomes quite impossible to strip off the epidermis from exactly the same region of each leaf. (2) It is difficult or impossible to trace the leaf patterns exactly. In addition, (3) differences in relative humidity of the atmosphere on different days, with consequent differences in moisture content of the paper, introduce errors in the weighing of paper patterns. Furthermore (4) there was a ponderable lack of uniformity in the paper used for tracing. In spite of these obvious deficiencies in methods, the data are regarded as serviceable approximations, useful in comparing the hairiness of any two plants of one variety and also in comparing the hairiness of different varieties.

STRUCTURE OF GLANDULAR HAIRS

A variety of structural complexity is exhibited by the glandular hairs occurring on *Nicotiana*. Those of simplest design, when young, are composed of a single, cylindrical basal or stalk cell and a single, spherical or ellipsoidal, apical gland-cell (fig. G). As a result of elongation of this stalk-cell and the development of horizontal cross walls the stalk may become multicellular although the apical cell may remain unicellular. On the other hand, the apical cell may become multicellular by the formation of horizontal walls only, or of anticlinal and periclinal walls also (figs. C, H, S), while the stalk cell may remain unchanged (figs. C, I), or, as another alternative, both basal cell and apical cell may coincidentally become multicellular (figs. A, B, H, I). Occasionally branched hairs, having a gland at each tip, are formed (fig. B).

It seems proper to consider glandular hairs of *Nicotiana*, regardless of the simplicity or complexity of their design, as *special organs*, for the following reasons: (1) Within each such gland are several green plastids. By appropriate microchemical tests it may be demonstrated that the color is imparted by chlorophyll. The presence of chlorophyll was demonstrated by removing the hairs, treating them while on a microscopic slide with 25 per cent HCl or glacial acetic acid, then heating the preparation to 90° C, whereupon, after a brief period, long brown needle crystals, that were soluble in ether or chloroform, were produced. The presence of chloroplasts within the glands makes possible the elaboration within them of photosynthetic products that could, in turn, be utilized *in situ* in chemosynthetic processes. Such a condition is by no means unique, because chlorophyll-bearing hairs are

known to be not uncommon among plants. For example, as long ago as 1882, Haberlandt (Netolitzky 1932, p. 48) noted chloroplasts in the hairs of *Rubus odoratus* L., *Melandryum viscosum* Čelak., and *Urtica dioica* L. He gave the name "lokalassimilatorischen Zellen" to such glands because they are sepa-



FIGS. A–I. Hairs of oriental tobacco. Figs. A, B, C, and D drawn to one scale; Figs. E, F, G, H, and I to the other. FIG. A. Glandular hair having three stalk cells and multicellular gland that is divided by planes at right angles to each other. FIG. B. Branched glandular hair. FIG. C. Short glandular hair with one stalk cell and many-celled gland. FIG. D. Trichome lacking gland. Some hairs appear never to become glandular and from others the gland may become dislodged. FIG. E. Tip of glandular hair. The gland cells contain chloroplasts and crystals. Exudate has accumulated beneath the cuticle. Droplets of exudate have lodged on the stalk. FIG. F. Two-celled gland with accumulated exudate beneath cuticle. FIG. G. One-celled gland with droplet of exudate adhering to stalk. FIG. H. Short-stalked multicellular hair as seen from above. FIG. I. Hair of the same kind as in figure H, when viewed from the side.

rated by chlorophyll-free cells from the assimilatory tissue (chlorenchyma, in leaves) and because they elaborate substances of a special kind.

(2) Crystals that are generally conceded to be by-products of metabolic processes, i.e., of respiration and perhaps also of synthesis of resinous substances by *Nicotiana*, occur within the gland cells, as revealed by direct

microscopic examination (figs. E, G, H, I). As long ago as 1888, Wakker (Netolitzky 1932, p. 49) drew attention to the presence of crystals within tobacco hairs. These crystals are to all appearances of the same kind as those within leaf mesophyll.

(3) The wall of the gland cell or cells is composed of two distinct membranes, the wall proper and a cuticular tegumen or cuticle. The former is mainly cellulosic as demonstrated by reaction with chloriodide of zinc, and the latter is cutinized, as indicated by reaction with Sudan IV. Apparently as the resinous materials (a mixture of waxes and ethereal oils) are elaborated and secreted, they accumulate between the wall and the cuticle to form a bleb. Eventually the secretions have accumulated in such volume as to rupture the cuticle, whereupon they appear external to the hair as droplets or as films that adhere to the hairs (figs. E, G, I) or spread out over the leaf surface. The wall proper remains intact, however, and the gland may continue for an indefinite period to synthesize and secrete the resinous exudate. Observations indicate that leaves are mature, and hence prime, at a time corresponding with that of greatest glandular activity. Proof of such correlation must remain lacking, however, until methods for measurement of leaf maturity and of rate of glandular activity have been perfected.

Whether the secretions from glandular hairs of tobacco *early* accumulate in blebs, as described above, or whether the blebs form *late* remains, however, a controversial matter. Tunmann in 1913 and 1914 (Netolitzky 1932, p. 149[3]) held that they do not form blebs early. He classified glandular hairs as oil druses, fat druses, and wax or resin druses. He stated that the hairs of *Nicotiana* and other Solanaceae are examples of the latter kind, and that the waxes are emptied to the exterior as rapidly as they are formed. Secretion by fat druses takes place in a similar manner, according to him. Chodat (Netolitzky 1932, p. 152[4]) concluded that the secretions of *Nicotiana* might be regarded as myelin, i.e., fatty materials, hence he would regard the glandular hairs as fat druses.

Feher (1923), from studies of resin secretion by *Populus*, came to the conclusion that there is no accumulation of secretion between the cuticle and cellulosic wall so long as the former remains permeable. When finally the gland wall becomes impermeable, however, then the cuticle is raised up, and the pressure exerted on it could eventually cause its rupture. On the other hand, Klug (1926) found that the oily secretions by *Mentha piperita* accu-

[3] "Wir müssen bis jetzt, wenn wir von den Kolleteren und den Schleimdrüsen absehen, unterscheiden: Öldrüsen, Fettdrüsen, und Harzdrüsen. . . . Bei den Fettdrüsen . . . sammelt sich die Sekret nicht subkutikulär an, sondern wird sofort nach aussen entleert. Zu den Harzdrüsen gehören beispielweise die keulenförmigen Drüsen der Solanaceen. Bei. diesen findet ebenfalls keine subkutikuläre Ansammlung statt, das gebildete Harz wird sofort nach aussen entleert."

[4] "die Ausscheidung der Drüsen von . . . Nicotiana die wohl auch nur als Myelinbildung gedeutet werden können."

mulate beneath the cuticle to make, at maturity, bladder-like vesicles, and that such secretions could be dissolved out to leave the cuticle intact.

It is found that oriental tobacco leaves possess their entire complement of hairs by the time they are from one-fifth to one-fourth their mature size. This fact was established from a series of determinations of total hair population on expanding leaves, employing for this purpose "bud" leaves that were destined to occupy the median stalk region.

DEVELOPMENT OF HAIRINESS

In a previous report (Wolf and Jones 1944) the conclusion was drawn that each leaf on any given plant of oriental tobacco tends to have the same hair population. The data upon which this conclusion was based were secured from examination of leaves selected at random from consecutive primings of

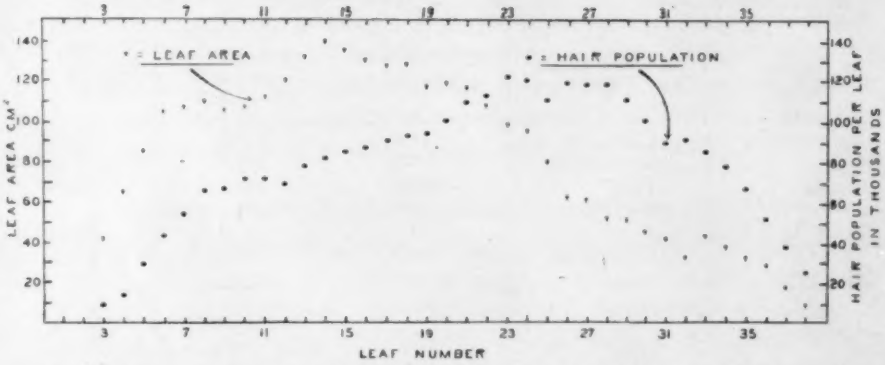


FIG. 1. A composite graphic portrayal of leaf size and total hair population of four varieties of oriental tobacco grown under glass during winter and early spring.

each of four varieties. It seemed that this conclusion would be more decisively established were one to use, in sampling, a sufficient number of selected plants from which every leaf was removed for analysis. Accordingly four varieties were employed in such an analytic study, but the number of individuals of each kind was perforce limited to six. These plants were grown under glass during the winter and spring of 1943–1944, as previously indicated. They were transplanted into porous, earthenware pots, but in so doing the first and second leaves were destroyed. However, the hairiness of similar leaves on seedlings that were not transplanted and also of cotyledons on such seedlings were determined. As regards cotyledons, it was found that they entirely lack hairs. As regards the first true leaf, it was found that it bears few hairs, and that these hairs are restricted, for the most part, to the principal veins and leaf margins. A considerably larger number of hairs occurs upon the second leaf, however, than upon the first one.

As each leaf above the first and second ones matured it was removed for determination of leaf area and hair population. An average was made, according to leaf position, of these determinations for each of the four varieties. Then from these averages a composite figure for all leaves of corresponding position was derived. Pertinent data from these composite figures are presented graphically in figure 1. It is apparent from figure 1, first of all, that under the conditions of these experiments, each leaf on any given plant is not equally hairy. Instead hair population tends to increase rapidly and progressively with increase in level of attachment until approximately the eighth leaf. It may be recalled, at this juncture, that the lower six to eight leaves are usually not included among harvestable ones when oriental

TABLE 1. *Differences in leaf size and hair population between field-grown and greenhouse-grown oriental tobaccos.*

Variety	Location grown	Average leaf area, cm.²	Average number hairs per leaf in thousands	Average number hairs per cm.²
Ayassolouk	Field	147.6	183.2	1240
	Greenhouse	123.3	101.7	825
Broussa	Field	149.6	259.2	1734
	Greenhouse	92.6	105.5	1140
Izmir	Field	131.2	159.5	1215
	Greenhouse	88.8	70.7	796
Stanimaka	Field	152.0	205.3	1350
	Greenhouse	115.0	119.6	1040

tobacco is grown in the field. Throughout a region above the eighth leaf, and extending to the twenty-eighth, the trend of increasing hair population per leaf continues but it is quite gradual. The difference in number of hairs on leaves nearest each other throughout this region is slight. With further progression along the uppermost region, however, each leaf may have a lesser number of hairs, a decline that may be related causally to nutrition. Difference in hairiness as displayed by leaves at different levels on greenhouse-grown plants is plainly at variance with findings when these same varieties of tobacco were grown in the field during the previous year (Wolf and Jones 1944). Moreover the number of hairs per leaf of plants grown under glass is strikingly less than that of plants of the same varieties grown in the field. A reason for these discrepancies was therefore sought by again analyzing hairiness on these varieties, when grown in the field. Resultant data on comparative varietal differences in average hair population and in leaf size of plants grown under glass and of plants grown outdoors are shown in table 1.

It should be recalled in interpreting the data in table 1 that each plant of any given variety of oriental tobacco tends to bear the same number of leaves, i.e., that fixity in leafiness is a varietal characteristic. Fixity of leafi-

ness, moreover, tends to be maintained regardless of the environment. In each of the four varieties, in table 1, larger leaves having a greater population of hairs were produced when the plants were grown in the field than when grown indoors. These data on leaf-size differences indicate that leaves on plants grown in the field may range from 20 to 60 per cent larger than those grown under glass, that the former has a greater hair population per unit area, and that they may have from 70 to 140 per cent more hairs per leaf. What is more significant than these differences is the fact that on field-grown plants each leaf on any given plant tends to have the same total hair population. It would seem therefore that an interpretation of these differences in hairiness must assume that hairiness is conditioned by two fundamental factors, one hereditary and the other environmental. If hereditary factors alone were operative hair population should tend to be the same regardless of environment. The fact that the upper leaves tended to become more and more hairy with the advance of spring when plants were grown indoors, and that they tended to be uniformly hairy when plants were grown in the field, seems to be due predominantly to environmental factors, presumably light. Further consideration of the matter of environmental effects on hairiness, however, will be given subsequently in this report.

HAIR POPULATION ON LEAVES OF DIFFERENT VARIETIES OF TOBACCO

That different varieties of oriental tobacco are preceptibly different in density of hair population is apparent even from quite casual observation. Manifestly the scope of these differences can be appreciated only if data on comparative measurements are available. The present purpose therefore is to express these differences numerically and thus, at the same time, to determine whether a basis exists for attempts to increase hair population per unit area by selection. All varieties considered herein were field-grown under as nearly as possible similar conditions of spacing, fertilization, and cultivation. It should also be borne in mind that all parent plants grown during the four preceding seasons had been bagged to prevent hybridization of varieties. The results of analyses of varietal differences are portrayed in table 2.

Among the varietal differences in hairiness shown in table 2, three are outstanding. First, the hair population per leaf may range from less than 100,000 to over 500,000. Second, within certain varieties there is a narrow range of difference in hair population between individuals, whereas in other varieties the leaves of certain plants have 50–100 per cent more hairs than do others. Third, there is a wide range in hair population per unit area of leaf surface, for some varieties have approximately twice as many hairs per unit area as do others. These differences would indeed have significance if, by selection of seed plants with greatest density of hairs, the average hairiness could be increased, since thereby the volume of aroma should also be in-

creased. Work of selection, to test this possibility, is in progress and the results should appear in a subsequent report.

TABLE 2. *Varietal differences in field-grown oriental tobaccos.*

Type	Time of maturing	Varietal name	Number leaves per plant	Average number hairs per cm.^{2}	Average leaf area per cm.^{2}	Total hair population per leaf in thousands			Range of hairiness as per cent
						Average	Maximum	Minimum	
Samsoun	Early	Persician (Prosetchan)	22–24	969	215.8	206.0	240.3	153.6	42.1
	Early	Samsoun	28–30	921	153.7	183.6	206.9	156.9	40.9
	Late	Broussa	38–45	1758	149.6	259.2	289.9	241.9	18.4
	Early	Samsoun (E)	26–28	1189	144.1	165.6	185.5	161.2	14.1
	Late	Dere	35–40	1438	179.9	255.7	327.5	200.4	49.7
	Median	Samsoun (G)	28–30	1440	113.9	158.7	201.1	128.0	51.7
	Late	Katarini	36–38	1201	130.3	142.4	189.3	92.2	68.2
	Late	Katarini (M)	36–38	1054	231.7	233.1	279.9	198.1	35.1
	Late	Katarini (W. L.)	36–38	1604	125.1	198.9	217.3	179.6	18.5
Smyrna	Late	Izmir	35–40	1222	131.2	159.5	199.3	151.4	29.6
	Late	Smyrna	28–30	1770	143.7	245.0	267.7	235.0	13.3
	Late	Ayassolouk	39–46	1267	147.6	183.2	331.9	115.6	118.0
Cavalla	Late	Jalomita	21–24	1397	362.5	502.5	599.3	431.9	33.5
	Early	Molovata	24–28	942	244.5	227.9	272.8	195.6	33.9
	Median	Ghimpati	26–30	1307	188.5	243.4	284.7	208.8	31.1
	Median	Stanimaka	33–36	1385	152.0	205.3	250.6	184.9	29.9
Xanthi	Early	Dragasani	22–24	869	134.6	114.4	126.7	85.7	35.8
	Early	Xanthi-Yaka (R)	22–24	996	137.0	135.2	143.3	132.1	8.2
	Early	Xanthi-Yaka (G)	22–25	878	93.4	82.0	90.1	64.4	30.3
	Median	Ustina 60	24–28	1266	144.9	181.8	233.8	150.4	45.9
	Median	Ustina 45	27–30	1350	179.2	234.6	281.3	173.8	45.8
	Median	Ustina 42	27–29	1387	148.1	197.9	242.9	147.8	48.0
	Early	Yenidge	23–25	1019	148.0	149.3	159.8	134.8	16.8
	Early	Yenidge 134	20–24	1166	138.1	152.4	202.4	133.6	55.0
	Early	Djebel	20–24	1099	92.4	99.6	105.5	92.3	13.2
	Early	Xanthi-Yaka (G2)	22–24	1723	66.9	114.3	124.8	97.7	23.7
	Early	Hendek	27–32	990	182.6	178.7	202.8	144.7	32.5
	Early	Goli Ruchki	21–24	904	149.7	140.1	202.5	82.3	83.7
	Early	Stob	21–24	885	165.6	143.4	189.3	92.1	68.2

It is believed that significance should be attached to date of maturity in interpreting the data in table 2. Those varieties having 20–24 leaves tend to mature early, those having approximately 30 leaves tend to mature at mid season and those having 35 or more leaves are late-maturing. Observations

on these varieties may be interpreted to show that tobacco of most satisfactory yields and with best quality have been secured from kinds that mature late, have the largest per unit area hair population, and produce leaves of median size. In any event, hairiness seems to be a tool that may be used in evaluating oriental tobacco prior to curing.

Attention might well be directed to a feature associated with each of these varieties of oriental tobacco, namely the existence of differences in aroma. Some varieties have very distinctive odors even before the leaves are primed. The causes of these differences are quite unknown but seemingly should be related to differences in proportion of ethereal oils and waxy materials of which the exudate is composed.

DECLINE IN HAIR POPULATION OF UPPERMOST LEAVES

It is well appreciated by tobacconists that, with oriental tobacco, cured leaves of poorest quality are usually obtained from the first priming, and

TABLE 3. *Trend in leaf size and hair population of the uppermost leaves of field-grown tobacco, Ayassolouk variety.*

Leaf position	Average area cm.²	Average number hairs per cm.² in thousands	Average number hairs per lower leaf surface, in thousands
Top leaf	15.2	3.5	53.7
2nd leaf from top	20.2	3.3	65.0
3rd leaf from top	29.8	3.2	97.0
4th leaf from top	35.3	2.8	100.6
5th leaf from top	41.4	2.7	112.5
6th leaf from top	45.3	2.6	120.2

that usually with each successive priming thereafter the quality of the crop improves. In some cases, however, tobacco of best quality is not produced from leaves along the uppermost stalk region. Unfavorable weather near the close of harvest, especially excessive rainfall or extreme drought, are conceded to contribute causally to decline in quality. Whether, as a proximate causal factor, decrease in hair population is correlated with decline in quality of uppermost leaves was given consideration, with the results shown by data in table 3.

Two facts are obviously established by the data contained in this tabulation. (1) Total leaf size and total hair population per leaf increases from the top leaf downward quite uniformly; and, as must follow, (2) with increase in leaf size, the hair population per unit area tends to decrease quite uniformly. The rate of subsequent change with downward progression is shown by the fact that unit-area population on the sixth leaf is approximately twice that of the average leaf of the variety Ayassolouk as shown in table 2.

That decline in quality of uppermost leaves is actually correlated causally in any case with decrease in total hair population seems highly improbable, however. This statement may at first seem to contradict the underlying correlation of hairiness and aroma. Even though these uppermost leaves have the larger glandular hair population per unit area, and therefore may be presumed to be more aromatic, yet quality undoubtedly depends upon such other factors besides hairiness, as leaf texture, size of component cells, compactness of constituent cells, chemical composition (both organic components and minerals), maturity of leaves when primed, proper curing, and proper subsequent manipulation.

The proximate causes of decline in hair population of leaves near the top of the stalk remain wholly unknown. It seems probable, however, that these causes are related to senility of the plant as a unit and to modification of physiological processes within these uppermost leaves as influenced by priming, nutrition, and other factors.

EFFECTS OF SPACING

The cultural practice of close-spacing, as employed in growing oriental tobacco, intensifies competition between individuals for water, nutrients, and light. The intensity of this competition is reflected by degree of resultant dwarfing. It seemed probable that hairiness might also be affected by competition, at least in some degree commensurate with such gross structural features as change in size of plants and size of leaves. In attempts, therefore, to measure influence of spacing on hairiness, three varieties of tobacco, an oriental, a flue-cured, and Burley, were transplanted into the field in such manner that there were eight times as many individuals per unit area of land in plots having closely spaced plants as in those having widely spaced ones. The same amount of manure per unit area of land was applied before transplantation, except that to the plot with widely spaced flue-cured plants supplementary inorganic nitrogen and phosphorus were added. As selected plants in these plots approached maturity, all their leaves were harvested for analysis, and the results have been summarized in table 4.

Under these conditions the average total leaf area of a widely spaced plant was from two to three times greater than that of a closely spaced one and each plant of the latter kind had approximately 60–75 per cent as many hairs as the former. The average size of leaves on closely spaced plants was approximately half that of those on widely spaced ones; then too, the average number of hairs per leaf on closely spaced individuals was very materially smaller. The density of hair population was, of course, correspondingly greater on the closely spaced plants. These differences in hair population and density between corresponding sets of plants cannot be ascribed to any single factor comprising the spacing complex. The experiments with ferti-

lizer materials, next to be presented, constitute an attempt to isolate the environmental factors that interact in spacing. In any such studies it seems reasonable to suppose that a pattern of hairiness exists, and that environmental factors operate through a fixed pattern of hairiness. By this connotation is meant that the ratio between epidermal cells having glandular hairs and those lacking them, tends to be fixed by mechanisms internal to the leaf, but that control of orderliness in this design may be disturbed within a limited range by external factors. Evidence that tends to support this concept appears from results, that follow, of experiments to isolate the nutritional factor.

TABLE 4. *Influence of spacing on hairiness.*

Variety of tobacco	Spacing	Average total leaf area per plant, cm.²	Average total number hairs per plant on lower leaf surface in thousands	Average size of leaves, cm.²	Average number hairs per leaf on lower leaf surface, in thousands	Average number hairs per cm.² on lower leaf surface, in thousands
Ayassolouk	Widely Spaced	8,037	8,647.8	254.3	273.7	1.1
	Closely Spaced	3,320	5,743.6	114.5	198.1	1.7
White Burley	Widely Spaced	12,350	13,574.8	617.6	678.7	1.1
	Closely Spaced	6,870	8,459.9	343.9	423.0	1.2
Flue-cured No. 401	Widely Spaced	11,790	18,435.5	539.4	927.8	1.7
	Closely Spaced	4,510	10,106.9	225.4	505.3	2.2

INFLUENCE OF FERTILIZER ON HAIRINESS

Even though a complex of interacting factors that are quite inseparable was concerned in the foregoing experiments with spacing, nevertheless partial separation of the nutritional factors was sought by comparing the effects on hairiness of application of a fertilizer, almost entirely organic, with one, almost entirely inorganic. These experiments involved plants grown closely-spaced. The results secured are assembled in table 5.

In explanation it may be stated that growth was more rapid and the plants were larger in the case of those supplied with inorganic nutrients. This difference is reflected in the average leaf sizes which were approxi-

mately 250 cm.^{2} and 340 cm.^{2} for plants grown with organic fertilizer and with inorganic fertilizer, respectively. The numbers of hairs per unit area of lower leaf surface were essentially identical in the two cases, being 1694 and 1709, despite the fact that the average size of leaves from plants supplied with inorganic fertilizer was 34.7 per cent the greater and the average hair population was 36 per cent the greater. From these results it seems reasonable to assume (1) that leaves of both groups of plants possessed equal numbers of non-hair-bearing, epidermal cells, (2) that a proportionality between hair-bearing and non-hair-bearing epidermal cells was maintained in each case, and therefore (3) that the larger size of component cells and not

TABLE 5. *Influence of fertilizer on hairiness.*

Environment	Average leaf area, cm.^{2}	Number hairs per cm.^{2}	Average number hairs per lower leaf surface
OS and OF	253.5	1,694	429,429
OS and FF	341.8	1,709	584,136

OS = Plants spaced closely as is done with oriental tobacco.
OF = Fertilizer of a kind (organic) known to be suitable for oriental tobacco culture.
FF = Fertilizer of a kind (largely inorganic) known to be suitable for flue-cured tobacco culture.

greater number of cells accounted for the larger size of leaves on plants supplied with inorganic fertilizer.

INFLUENCE OF LIGHT ON HAIRINESS

No experiments have been attempted to evaluate decisively the extent to which light affects hairiness. However, in connection with the results in figure 1 which portray progressive increase in hair population with advance of the season, as has been indicated previously, it seems reasonable to ascribe this increase to light as a prime causal factor. Some support for this conclusion stems from an analysis of these composite figures showing leaf size and hair population. The group of largest leaves, 12–16 inclusive, was harvested during the period April 7–13. The group of leaves, 23–28 inclusive, possessing the largest hair population, was harvested May 17–26. Manifestly quite different light conditions prevailed, during the critical period of early expansion of those groups of leaves. The average leaf area of the former group is approximately 130.6 cm.^{2} and hair population 79.5 (in thousands); corresponding average figures for the latter group are 71.3 cm.^{2} and 117.5 (in thousands) respectively. That light induces responses through a numerical pattern between hair-bearing and non-hair-bearing cells is unknown in this instance, and such possibility must await determination. Evidence that response of this sort occurs rests, at present, mainly upon the fact that hair

population of a given leaf becomes fixed by the time the given leaf has attained from one-fifth to one-fourth its mature size.

SUMMARY

That aroma arises primarily from exudate of glandular hairs was concluded from previous studies of the structure of leaves of oriental tobacco. It seemed desirable, therefore, to acquire more knowledge of hairs, herein regarded as secretory organs, to serve as a basis for attempts to increase hairiness, and thereby to increase the volume of aroma. To this end studies were made both of hair structure and of hairiness.

The gland cell or cells contain chloroplasts, as has been reported by others. These photosynthetic structures are lacking, however, in the stalk cells and in the epidermal cells from which glandular hairs arise. Chloroplasts within glands enable them to synthesize exudate *in situ* and eventually to excrete it. Elaboration and excretion of exudate may continue throughout the entire period that the leaf remains functional. The exudate from different varieties is quite unlike, as judged by the sense of smell. In fact, certain varieties possess an odor that is quite distinctive.

The density of hair population and total number of hairs per leaf differ according to the variety of oriental tobacco. The range in hairiness is rather wide, as shown by the fact that certain varieties have approximately twice as many hairs per unit area as do others. These characteristic varietal differences are not immutable however, but are subject to modification and control both by hereditary and environmental factors that act interrelatedly. Present observations indicate that partial separation of such interaction can be accomplished.

As regards findings that may be attributed to controls exerted by hereditary factors it has been noted (1) that differences exist in hair population per unit area of leaf surface and per entire leaf, when different varieties are grown under identical environmental conditions; and (2) that all individuals of certain varieties may have quite the same number of hairs per leaf whereas certain plants of other varieties may have approximately twice as many hairs per leaf as others.

Differences in hairiness between individuals that come from one and the same seed plant indicate that hairiness may be increased by selection. If such an eventuality were to be realized new strains having a greater volume of aroma should be the outcome.

As regards findings that seem traceable to controls induced under the influence of environmental factors the following have been noted: (1) Wide differences in hairiness occur within one and the same variety when grown under glass during the winter season and when grown in the field during summer. Plants grown during winter are much less hairy than those grown

during summer. Under the influence of wide variation in environment during early spring there was lack of uniformity of hair population per leaf whereas during the more favorable environment of summer each leaf had quite the same number of hairs. (2) Many more hairs per leaf are produced by plants of one and the same variety when grown widely spaced than when grown closely spaced. The leaves on widely spaced plants may be from two to three times larger than those on closely spaced ones; the per unit area population of hairs in the former case, however, is very markedly less than in the latter.

The number of hairs on leaves along the basal stalk region and near the tip is always different from that of leaves along the main portion of the stalk.

None of the interrelated factors, including nutrition, water, and light, involved in the experiments with spacing, has been resolved adequately. As having bearing on nutrition, observations indicate that tobacco plants grow more rapidly and are larger if they are supplied with readily available nutrients than if the nutrients are slowly available. Such larger plants with larger leaves have the greater total hair population. Determination of density of hairs on leaves, total hair population, and leaf area, indicate, for these two sets of plants, i.e., widely-spaced ones and closely-spaced ones, the existence of a pattern of hairiness. As having bearing on light, hairiness is increased with increased illumination.

Insofar as hairiness is correlated (1) with time of maturity of a given variety, (2) with leafiness, and (3) with desirable leaf size, it seems to be a criterion by means of which an evaluation can be made of the leaf prior to curing. It is indicated that further knowledge of environmental influences upon hairiness should be sought.

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CYTOPLASMIC HYBRIDS IN PENICILLIUM NOTATUM

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Derx (1925) mated the cultures from twelve single spores of *Penicillium luteum* in all combinations and Shear and Dodge (1927) state, "Derx . . . has proved conclusively that *Penicillium luteum* is heterothallic." Emmons (1935) has shown that single ascospores isolated from *P. luteum* produce perithecia but this does not invalidate Derx's conclusions, for closely related fungi are known to produce both homothallic and heterothallic forms. Since Derx proved the existence of heterothallism in some *Penicillia* we purposed to investigate the question of the existence of heterothallism in this so-called species.

P. notatum is a *form* species rather than a *true* species. The fact that it is isolated rather frequently from nature is the only basis for giving it specific status and most systematists recognize that calling it a species is a necessary and useful violation of the species concept. It probably originated from *Penicillium* ascospores and is perpetuated in nature asexually. *P. notatum* is identified as a species only by its morphological characters and the structure of the penicillus suggests that it may be a degenerated form of a more vigorous parent. In *Neurospora* a vigorous, well developed conidial form may produce a large number of different kinds of much inferior progeny. It is possible that *P. notatum* is genetically sterile at its origin or that variation has altered the mating-type specificity and that it is incapable of producing hybrids. It may be significant that Derx mated the cultures which he obtained from single ascospores very shortly after having isolated them. If the same cultures had been tested a few months later they might have been incapable of producing perithecia. A parallel situation is found in yeasts. Lindegren and Lindegren (1944) have shown that haploid yeast cultures capable of copulating vigorously may lose their mating-type specificity and become completely sterile when carried in culture. Lindegren, Beanfield and Barber (1939) described variations in the fertility of *Neurospora* cultures.

Twenty-five cultures of *P. notatum* of the P. S. (*Penicillium Survey*) series collected from a variety of sources were obtained from Dr. Raper of the Northern Regional Research Laboratory. These cultures had all been dried *in vacuo* and sealed in glass tubes shortly after isolation. Cultures grown from these lyophil tubes were paired in 183 combinations on molasses-peptone-agar slants and carefully observed to see if perithecia were produced. No perithecia were found a month later, although *P. luteum* sporulated

* Supported by a grant from Anheuser-Busch, Inc.

abundantly on this agar within a week. This experiment seemed to limit or exclude the possibility of making true hybrids in *P. notatum*, so an attempt was made to produce heterokaryons between these different cultures. Foster, Woodruff and McDaniel (1943) have shown that *P. notatum* becomes heterokaryotic by mutation, with a rapid loss of penicillin-producing ability. They found that the new mutants which occurred in the mat seemed to decrease its capacity to produce penicillin.

Baker (1944) showed that the septations in *P. notatum* are perforate and that fusions between germinating spores and between different hyphae occur frequently. Her figures suggest that conditions in *Penicillium* may approximate those in *Neurospora*, in which heterokaryosis is extremely important, especially for survival in nature. Lindegren (1934) has shown that heterokaryosis is so advantageous to the filamentous fungi that it is probably the natural condition for all of them.

Hansen (1938) has described the "dual phenomenon" in a wide variety of fungi, and Hansen and Snyder (1944) have made observations on *P. notatum*, which they conclude also exhibits the "dual phenomenon." What Hansen referred to is obviously simple heterokaryosis. Previously to Hansen's work, both Dodge (1928) and Lindegren (1934) had shown that heterokaryosis is the rule in *Neurospora* and, furthermore, that the condition is not "dual" but multiple. The commonest type of mutation involves loss of the ability to produce conidia. Lindegren (1936) found at least ten different nonconidial mutants in *Neurospora*, all of which were non-allelic. To speak of a heterokaryon of conidial and nonconidial forms as a "dual phenomenon" oversimplifies the situation. The nonconidial mutants are easy to detect by observation. This is especially true in *P. notatum* and may be due to the fact, recently discovered by Pontecorvo and Gemmell (1944), that the nonconidial form may be dominant in the heterokaryon. However, in addition to nonconidial forms, natural heterokaryons contain a number of other types of mutants.

EXPERIMENTS

The first step in the formation of heterokaryons is hyphal fusion, and our first experiments were designed to test the readiness with which fusions occur between different cultures of *P. notatum* and to select strains which were able to anastomose readily. The fact that hyphae fuse has no significance from the standpoint of mating type or sexual difference. It is characteristic that some cultures are able to fuse more readily than others. In one mycelium fusions may occur readily between adjacent hyphae, while in another strain of the same species practically no fusions will occur.

The experimental procedure was as follows: Sterile slides were coated with a thin layer of nutrient agar and parallel streaks of conidia from a

single *P. notatum* culture were made on each slide with the inoculating needles adjusted so that the points were approximately 2 mm. apart. These slide cultures were allowed to incubate at room temperature (about 80° F). In most cases conditions were optimum for observation at 48 hours. Fusions between the hyphae could be observed in the region between the parallel streaks at 48 hours, but after the second day overgrowth generally obscured precise observations.

Three of the 25 N.R.R.L. strains of *P. notatum* showed a marked tendency to fuse, seven others did so with somewhat less vigor, and the remainder either demonstrated a pronounced reluctance to fuse or the mycelium failed to grow across the intervening space. In very few cases did fusions occur with any of the strains where the parallel streaks were more than 3 mm. apart. When the streaks were from 3 to 5 mm. apart the mycelia would advance to within about 1 mm. of each other and growth on the inner sides would cease, although it continued on the outside. The three N.R.R.L. strains, No. 49, No. 72, and No. 75, each of which had demonstrated a strong tendency to produce hyphal fusions with themselves, were matched in pairs on agar slides. The three possible pairings all exhibited abundant fusions after two days. This is exceptional, for in most other instances where the parallel streaks originated from two different strains, a pronounced barrage occurred.

When fusions occurred between two different strains a transfer was made to an agar slant and the resulting culture was studied carefully for uniformity. In no case were sectors observed, and the mycelium was always intermediate in roughness and other observable characters. Since the previous tests had shown that the mixed mycelia were compatible, we concluded that the combinations produced heterokaryons rather than fungal mixtures.

Hyphal fusion is not a mating-type or a sexual phenomenon and there is no apparent limit to the number of genotypes which can be built into one heterokaryon. A triple heterokaryon was made by mixing Nos. 72, 75, and 49.

Culture No. 72 (which was most compatible from the standpoint of penicillin production) was paired with two cultures which we had been using in the laboratory for penicillin production. Mat cultures of all the original strains and the heterokaryons were grown in penicillin-medium in 2-quart milk bottles. All tests were run in triplicate and many in quadruplicate. The results were averaged, and the agreement in all cases was rather close. Before seeding the heterokaryons, the mixed cultures were grown on agar slants. The bottles were inoculated and kept one day at room temperature and 7 days at 23° C. The filtrate from the bottles was assayed by the Oxford method, using glass cylinders on an agar plate sown with staphylococci. The amounts of penicillin in Oxford units are shown in the following table:

Strain	Penicillin	Strain	Penicillin	Strain	Penicillin
No. 49	20	No. 49	18	No. 20.4	50
72	47	72	90	40.1	5
75	25	75	22	72	33
49 & 72	12	49 & 72 & 75	2	20.4 & 72	35
49 & 75	7			20.4 & 40.1	5
72 & 75	47			40.1 & 72	27

Culture No. 49 has a definitely destructive effect on the penicillin production of cultures with which it is associated. No. 75 and No. 72 seem to be compatible, if not complementary. No. 72 and No. 20.4 also seem compatible.

HETEROKARYONS IN NATURE AND IN THE LABORATORY

Under natural conditions many conidia usually germinate together and if the strains are compatible anastomoses immediately produce heterokaryons. Therefore, in mature heterokaryosis is an especially favored condition and opportunity is afforded for continued increase in complexity of the thallus. However, laboratory manipulation of fungal cultures leads to a different end. On agar plates single conidia germinate separately and cultures are selected which are of monoconidial origin. Many of these cultures are homokaryotic, and this is especially true of fungi such as *Penicillium* which has uninuclear conidia. The high lability of penicillin producton, as indicated by our experiments on heterokaryons, suggests that under natural conditions, where mixtures are the rule, little or no penicillin is produced. Only in the laboratory where homokaryons are handled, or when a single conidium falls in a plate (as in Fleming's original observation), can appreciable amounts of penicillin be expected. The possibility still exists, however, that the yield of penicillin may be increased by making mixtures. Dodge (1942), and Beadle and Coonradt (1944) showed that mutants deficient for certain physiological characteristics may mutually supply each other's deficiencies in a heterokaryon.

Because of our limited knowledge of sexuality in the *Penicillia* and *Aspergilli*, and the general conviction that with few exceptions these species are imperfect, attempts to improve penicillin production have been confined principally to the selection of supposedly imperfect cultures isolated from nature. But this program is very inflexible, for even if the isolation of a large number of different forms of *P. notatum* should yield exceptionally effective penicillin producers, improvement of the culture is limited by the potentialities of the original isolate because this so-called species apparently is incapable of mating and our own attempts at improvement by cytoplasmic mixtures do not show too much promise.

The fact that some penicillin producers are still using their original cultures indicates that an extensive search has not resulted in the discovery of greatly superior genotypes. The following procedure might yield improved forms: It should be possible to find an ascogenous heterothallic *Penicillium*

or *Aspergillus* with the ability to produce penicillin. Once this organism has been discovered its sexual mechanism can be exploited to produce different segregants, and those which are best from the point of view of penicillin production can be mated with each other, as well as with widely different forms. This method has been used successfully with yeasts (Lindegren & Lindegren 1945).

In *Neurospora* many, and probably most, of the isolates from nature are bisexual (heterokaryotic for both the A/a or +/– alleles) (Lindegren 1934) but sterility factors prevent copulation, so the mycelium appears to be unisexual. The most experienced observers may fail to detect such self-sterile bisexual heterokaryons. Lindegren (1936) has reported obtaining five cultures of *Neurospora* from Dr. B. O. Dodge, which were labelled Mexica A, Cuba A, Japan A, Japan B (= a), Panama B (= a). An elaborate series of experiments was required to show that all three of the A strains were bisexual, that is, they carried two kinds of nuclei (A and B, or A and a), but sterility factors prevented the production of perithecia.

Moreau and Moruzi (1931) performed experiments in which a culture of *Neurospora*, freshly isolated from nature, was planted in one side of a U-tube filled with agar, and a laboratory culture isolated from a single *Neurospora* ascospore (and therefore homokaryotic as far as sex is concerned) was planted in the other arm of the U-tube. Under such conditions the natural culture produced perithecia and ascospores. They proved conclusively that mycelium did not grow through the U-tube, so only the diffusion of some stimulating substance through the agar could account for the appearance of the perithecia. The culture which had been isolated from nature was incapable of producing perithecia except under these conditions. They concluded that this experiment proved that sex genes did not control the production of perithecia in *Neurospora*. Dodge (1932) and Aronescu (1934) criticized these experiments adversely, but Lindegren (1936) interpreted them as indicating that the culture which Moreau and Moruzi had isolated from nature was a bisexual, self-sterile heterokaryon which was made fertile by the diffusion of a substance from the homokaryotic culture. Lindegren (1934) suggested that self-sterile, bisexual heterokaryons occur frequently in nature among the filamentous ascomycetes because of their obvious high survival value. They enable the thallus to preempt a large area by virtue of its rapid vegetative growth but when vegetative growth has ceased the conidia can fertilize other thalli whether they be bisexual or unisexual. The practice of plating out *Penicillia* with their uninuclear conidia breaks up any heterokaryons which may be collected. In *Neurospora* the multinucleate conidia facilitate the maintenance of the heterokaryon.

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CHROMOSOMES OF CRUCIFERAE—II. CYTOGEOGRAPHY OF LEAVENWORTHIA[1]

J. T. BALDWIN, JR.

Torrey (1837) established *Leavenworthia* with two species: *L. aurea* and *L. Michauxii*, and listed *Cardamine uniflora* Michx. as synonymous with the latter; Gray (1880), recognizing that the genus "has been almost from the first involved in some difficulty as to the species," added *L. torulosa* and *L. stylosa;* Britton (1894) made the combination *L. uniflora.* Svenson (1941) observed that "the species . . . are still obscure." Here, in the present paper, it is attempted by cytogeographic means to interpret the entities of the genus: there seem to be four rather well defined species—those designated by Torrey and by Gray.

The Nashville Basin of Tennessee is the center of generic variability: for discussion and delimitation of the Nashville Basin see Fenneman (1938, p. 431–434 and pl. 6). Representatives of the four species occur together there (see figures 6–9); *e.g.*, a letter in the Gray Herbarium, under date of May 8, 1880, from A. Gattinger to Asa Gray, reads with reference to *Leavenworthia:* "I found this time . . . three species on one square yard of ground," near Nashville, Tennessee, and the specimen transmitted with that letter and from that spot is apparently of the fourth species, *L. aurea.* A balance of selective advantages among the species must exist. From that region the genus extends sporadically through Kentucky into Highland and Adams counties, Ohio, and into Clark County, Indiana, through much of Missouri into Kansas (*A. S. Hitchcock 34; Herbarium of Missouri Botanical Garden 213157*), through Arkansas to Choctaw County, Oklahoma, and as far south as San Augustine County, Texas, and Jefferson County, Alabama.[2] The plants are calciphilous winter-annuals: they characteristically grow on limestone.

Several years ago, with the help of a number of individuals—to whom appreciation is here expressed—the writer brought together twenty-seven living collections of *Leavenworthia* more or less representative of the geo-

[1] Contribution from the Department of Botany, University of Michigan, and from The Blandy Experimental Farm, University of Virginia.

[2] A specimen of *L. torulosa* of doubtful origin in Louisiana is in the Herbarium of the New York Botanical Garden, and one of indeterminate identity and questionable origin in Illinois is in the Herbarium of the Brooklyn Botanic Garden. In various herbaria are J. M. Coulter's specimens from Jefferson County, Indiana; it is explained in a letter of November 7, 1944, from C. C. Deam that those specimens were in all likelihood collected in Clark County. It is stated by F. C. Gates in a letter of October 31, 1944, that "while one might think that *Leavenworthia uniflora* might grow in Kansas, there is no evidence that I know of that it does, and no specimens in our state herbarium."

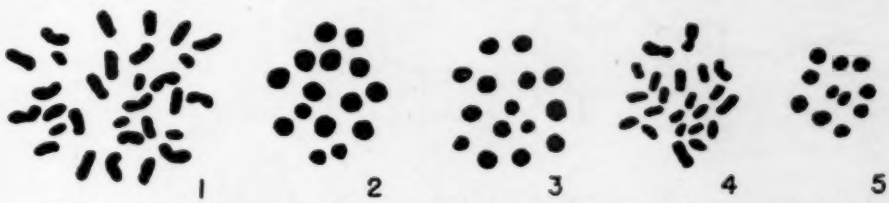
TABLE 1. *Collections of Leavenworthia for which chromosomes were counted.*

Species and source	*n*	2*n*	Collector	Author's number
L. uniflora (Michx.) Britton				
Missouri				
Franklin County: Gray Summit		30	Edgar Anderson	2550
Kentucky				
Caldwell County: Princeton		30	A. M. Harvill	2551, 2552
Simpson County: at Tennessee line		30	B, S & H[a]	2553, 2554
Tennesee				
Knox County: Mascot		30	A. J. Sharp	2555, 2556
Knox County: Hall's Crossroads		30	A. J. Sharp	2557, 2558, 2559
Wilson County: Lebanon		30	C. C. Deam	2560
Rutherford County: Murfreesboro		30	B, S & H	2561, 2562
Rutherford County: Murfreesboro		30	B, S & H	2563
Davidson County: Nashville		30	B, S & H	2564, 2565, 2566
L. torulosa Gray				
Tennessee				
Rutherford County: La Vergne		30	B, S & H	2567, 2568
Davidson County: Nashville	15	30	B, S & H	2569, 2570
Davidson County: Nashville	15	30	B, S & H	2571, 2572
Sumner County: Gallatin		30	C. C. Deam	2573, 2574
Brooklyn Botanic Garden	15	30	H. K. Svenson	
L. stylosa Gray				
Tennessee				
Wilson County: Lebanon (petals yellow)	15	30	C. C. Deam	2575, 2576
Wilson County: Cedar of Lebanon State Park (petals white or purple with yellow base)	15	30	C. C. Deam	2577, 2578
Wilson County: Lebanon (petals yellow or petals white or purple with yellow base)		30	B, S & H	2579, 2580
Wilson County: Lebanon (petals yellow)		30	C. C. Deam	2581, 2582
Rutherford County: La Vergne (petals yellow)	15	30	L. M. Dickerson	2583, 2584, 2592
Rutherford County: Murfreesboro (petals white with yellow base)		30	B, S & H	2585, 2586
Rutherford County: Murfreesboro (petals purple with yellow base)		30	B, S & H	2587
Davidson County: Nashville (petals yellow)		30	A. J. Sharp	2588, 2589
Davidson County: Nashville (petals yellow)		30	A. J. Sharp	2590, 2591
Davidson County: Nashville (petals yellow)	15	30	B, S & H	2593, 2594
Davidson County: Nashville (petals yellow)		30	B, S & H	2595, 2596
Brooklyn Botanic Garden (petals purple with yellow base)		30	H. K. Svenson	
L. aurea Torrey				
Tennessee				
Davidson County: Nashville	11	22	A. J. Sharp	2597, 2598

[a] J. T. Baldwin, Jr., H. T. Shacklette, and A. M. Harvill.

graphic range of the genus (table 1). The collections, with three exceptions, were grown from seed under uniform conditions in the University of Michigan Botanical Gardens. Certain plants of each species were isolated to determine the status of self-fertility for the species. The $2n$-number of chromosomes for each collection was established from aceto-carmine smears of leaves of young plants and from smears of roots of pot-bound plants; the n-number of chromosomes at microsporogenesis was ascertained for some of the collections. A comprehensive set of cytologically studied specimens of various ages has been placed in the University of Michigan Herbarium. Distribution maps for the four species are based upon specimens borrowed from eleven herbaria.[3] Many of the specimens were wrongly identified.

L. uniflora (Michx.) Britton is a clear-cut species and is seldom confused in the herbaria. Its leaves, in contrast to those of the other species, are finely



FIGS. 1–5. Chromosomes of *Leavenworthia*. FIGS. 1–3. *L. stylosa* Gray at mitotic metaphase and at first and second meiotic metaphase—$2n = 30$, $n = 15$. FIGS. 4, 5, *L. aurea* Torrey at mitotic metaphase and at first meiotic metaphase—$2n = 22$, $n = 11$. Note the six small chromosomes in *L. stylosa*. Magnification *ca* × 2000.

dissected "with many small sharp-toothed or angulate segments." In the nine collections grown (table 1) the petals were white with a yellow claw; upon drying, the petals often become yellowish, which is the basis for Torrey's (1837) "opinion that the flowers . . . are pale yellow." Gray (1880) described the petals as "white with purplish tinge." The silique is non-torulose and linear with a short, and usually stout, style. The $2n$-chromosome number for the plants investigated was thirty. This species has by far the widest distribution, being absent, it would seem, from only the southern and southwestern parts of the generic range (fig. 6).

[3] The herbaria of the United States National Museum, Chicago Natural History Museum, United States National Arboretum, New York Botanical Garden, Brooklyn Botanic Garden, Missouri Botanical Garden, Gray Herbarium, University of Kentucky, University of Tennessee, University of Michigan, and C. C. Deam Herbarium. For their coöperation the writer is grateful to the curators of these herbaria: it was a privilege to examine the specimens. Among the material borrowed from the New York Botanical Garden were designated types of *L. aurea* Torrey collected by M. C. Leavenworth in Texas (or Oklahoma?) and of *L. Michauxii* collected by C. W. Short in Kentucky and isotypes of *L. stylosa* Gray collected by A. Gattinger in Tennessee and of *L. torulosa* Gray collected by C. W. Short in Kentucky; among that from the Gray Herbarium, a photograph of the type of *Cardamine uniflora* Michaux, collected by him near Knoxville, Tennessee, and deposited in the Herbier du Muséum national d'histoire naturelle de Paris.

L. torulosa Gray is likewise usually distinct: leaves coarsely dissected, flowers light purple, fruit torulose and linear with prominent style. The species apparently intergrades somewhat with *L. stylosa*. The five collections investigated cytologically had $2n = 30$, $n = 15$ (table 1). The distribution area extends from Central Tennessee into Kentucky (fig. 7): occurrence of the species in Louisiana (see footnote 2) and at Allenton, Missouri, as

FIG. 6. Distribution of *Leavenworthia uniflora* (Michx.) Britton: big circles, specimens examined cytologically; little circles, specimens in herbaria.

evidenced by one plant of *L. torulosa* mixed on a sheet with *L. uniflora* (*Herbarium of the Missouri Botanical Garden 774303*), is questioned. Dr. C. W. Short's collections have indefinite citations of locality: "barrens of Kentucky" (type), "in the west of Kentucky," and "limestone cliffs of Kentucky river."

L. stylosa Gray is, with respect to flower and fruit, the most variable

species in the genus. It seems rather constant in foliage: leaves with relatively few angled or lobed segments. Thirteen collections were grown; the petals were yellow, or were white or purple (in differing intensity and pat-

FIG. 7. Distribution of *Leavenworthia torulosa* Gray: big circles, specimens examined cytologically; little circles, specimens in herbaria.

tern) with yellow base (table 1). Yellow is much the commonest color: it may be that entirely yellow petals occur in no other species of *Leavenworthia*.[4] The flowers of this species are big in comparison with those of

[4] Sharp (1940) would give varietal designation to a plant "with flowers identical in color with those of *Oxalis violacea*" (*R. E. Shanks & A. J. Sharp 386:* near Murfreesboro, Rutherford County, Tennessee); that seems not wise: such recognition requires comparable treatment for coordinate differences, of which there are others in this species; it appears far better in such cases merely to record variations rather than to use them for nomenclatorial notice with consequent systematic encumbrance. *R. M. Harper 3876* (near Isbell, Franklin County, Alabama) exhibits the same color pattern, as do a number of the specimens listed in table 1. The plant figured by Hooker (1868) has the same character and is referable here.

other representatives of the genus; the plant would make an attractive ornamental. The fruits are silicles with 3–6 seeds or many-seeded siliques to 25 mm. long and of variable width; styles are conspicuous and to a length of 6 mm. The chromosome number for twelve collections was $2n = 30$, $n = 15$ (figs. 1–3). The species has a restricted occurrence in Central Ten-

FIG. 8. Distribution of *Leavenworthia stylosa* Gray: big circles, specimens examined cytologically; little circles, specimens in herbaria.

nessee, in northwest Alabama (fig. 8), and in "Kentucky" (*Chicago Natural History Museum 790163*). Svenson's (1941) figure of *L. torulosa* belongs here.

Individuals of *L. stylosa* isolated in the greenhouses at the University of Michigan Botanical Gardens set few or no seed: the plants were highly self-sterile. Under the same conditions representatives of the other species were highly self-fertile. But when pots of *L. stylosa* were crowded together on the

greenhouse bench, the plants usually produced many seed: pollination between individuals probably occurred. In nature *Leavenworthia* generally grows in thick stands. It would be of significance to determine for a species that is highly self-sterile the relation between initial population size and the maintenance capacity: one would expect high positive correlation between the number of individuals and survival, and the same, of course, for a self-fertile group, but in less degree. Such differentials in survival have a direct bearing on the efficiency index of migration of species, and especially if one considers that often the entry of a species into a new locality is a matter of chance. If cross-pollination is obligate for *L. stylosa*, that might account for the instability and variation in the species: mutations would be assured trials in all combinations. The big and showy flowers suggest in this regard that the species is insect-pollinated, and differences in color frequencies might in some measure be explained thereby: East and Glaser (1914), for example, found in *Nicotiana* that certain insects effecting pollination showed marked preferences for given flower colors.

L. aurea Torrey has not infrequently been confused with *L. stylosa*. The type of *L. aurea*, from the Shortian Herbarium, was collected in Texas (or Oklahoma?) by M. C. Leavenworth, M.D., of the United States Army, and on his authority the label indicates that the plant has "flowers golden yellow." Thus the specific name. But it is altogether likely that the color was wrongly recorded, and the specific name, therefore, misleading. The only collection grown during the present study had white petals with yellow claws, and Small (1933) states that the petals are "white or purplish, except the yellow base"; this description seems to hold for the herbarium specimens examined by the writer, but colors cannot be determined with certainty from dried flowers. Gray (1880) noted that Alabama representatives of the species had "petals purple, pale rose, or white, with yellowish base, sometimes fully half inch long": he was not distinguishing between *L. aurea* and *L. stylosa*. *L. aurea* has leaves with relatively large, blunt-lobed segments, and in this resembles *L. stylosa* and *L. torulosa* and differs from *L. uniflora*. The silique is oblong-linear, non-torulose, and has a conspicuous style. The plants of the only collection studied cytologically had a chromosome number of $2n = 22$ (fig. 4) and $n = 11$ (fig. 5), which contrasts with the uniformity of $2n = 30$, $n = 15$, as known for the rest of the genus. Distribution is given in figure 9. As now understood, the occurrence of the species is disjunct. It extends farther south than any other species. The herbarium specimens from Texas and Oklahoma seem more robust than the plants from Alabama and Tennessee.

Indications are that *Leavenworthia* is predominantly hexaploid. At mitotic metaphase in *L. stylosa* six chromosomes are smaller than the other twenty-four (fig. 1); at first meiotic metaphase three of the fifteen bivalents

are clearly small (fig. 2); at second meiotic metaphase three of the chromosomes are smaller than the others (fig. 3). Moreover, the condition of $2n = 22$, n = 11, in *L. aurea* could well be interpreted as derived from a straight tetraploid of $2n = 20$, $n = 10$. Additional survey of the genus might reveal the existence of such a race, as well as of a diploid of $2n = 10$, $n = 5$,

FIG. 9. Distribution of *Leavenworthia aurea* Torrey: big circles, specimens examined cytologically; little circles, specimens in herbaria.

but, on the other hand, if there were such races of *Leavenworthia*, they may have been evolutionarily inept and may no longer exist.

And what about interspecific relations? On the evidence at hand *L. aurea* appears to be the oldest species: it has the lowest chromosome number; it occurs farthest south, and, since the genus is part of a flora that apparently receded under glacial influence, this specific range has significant meaning, particularly since the range is not continuous. *L. stylosa* might be inter-

preted as the hexaploid phase of the same complex and as the second oldest species: it is often confused with *L. aurea;* it is highly self-sterile; it is a group in which the "trial of variations" is in progress; it is an entity most likely to produce other entities that are distinct. *L. uniflora* can be considered such a product and as the third oldest species: it too is hexaploid, but self-fertile and, even when isolated, productive of many seed; it, perhaps fortuitously as well as from the result of certain advantages, can be assumed to have entered new territory and, in large measure, to have preëmpted the ecological situations available to the genus. *L. torulosa* is, accordingly, to be regarded as the youngest species: it is hexaploid and highly self-fertile but restricted in range. In its foliage, habit of growth, its somewhat large flowers of purplish color, and its longish style, the species shows affinity to *L. stylosa.*

L. torulosa and *L. stylosa* are in great degree within the Nashville Basin, as delimited by Fenneman; *L. aurea* and *L. uniflora* extend out from there. The Nashville Basin is a part of the Interior Low Plateau. The latter is bounded by the Cumberland Plateau, by the upward extension of the Coastal Plain province from the Gulf of Mexico, and, on the north, by the Till Plain, "in which an older topography like that of the Interior Low Plateau is buried" (Fenneman 1938). The rocks are Ordovician—"generally bluish-gray, fossiliferous limestone, and calcareous shales of varying characters; phosphatic in many horizons; knotty, earthy, and unevenly bedded" (Pond). Much of the Basin consists of "glades," as the more or less flat areas of bare rock, or rocky places, with all gradations between the proportions of rock to soil, from perfectly bare rock to rocky fields which can be farmed, are designated in Tennessee (Galloway 1919). And glades are of two types: red-cedar glades on platy, thin-bedded Lebanon limestone, or rarely Pierce; hardwood glades, usually on Ridley limestone, with "flat areas of solid, bare rock with few cracks," or "areas of massive or chunk rock with numerous joints or vertical cracks partially filled with soil" (Galloway 1919). These glades have a characteristic flora, of which *Leavenworthia* is a typical element.

The only other representative of this flora that has been subjected to detailed cytogeographic analysis is *Sedum pulchellum* Michx. (Baldwin 1943). It too is a calciphilous winter annual. Its range is just about the counterpart of that of *Leavenworthia* (see distribution map in Baldwin 1943). It consists of diploid, tetraploid, and hexaploid races: $2n = 22$, 44, 66. The hexaploid race, as known, is restricted to the Nashville Basin; the other two races, with extensive ranges, are also represented there.[5]

[5] Baldwin (1943) postulated that diploid *S. pulchellum* ($2n = 22$) might be the amphidiploid result of hybridization of a 5-chromosome line of evolution in *Sedum*—as now exemplified by *S. Nuttallianum* Raf. ($2n = 20$), with a present range from south-

How does one account for the similarities between the evolution patterns of these two complexes, one of the Cruciferae, the other of the Crassulaceae? It seems logical to consider that both complexes once occurred, via diploid representatives, to the north of their present ranges and on the older formations now covered by the Till Plain, but, with glacial advance, they moved south—or were killed out to at least the approximate latitude of Nashville, and on both sides of the Mississippi River. Then, one concludes, tetraploidy was established in the Nashville Basin for *S. pulchellum*, and, with recession of the glacier, the species moved northward again, to the east of the Mississippi as a tetraploid, to the west as a diploid: its migration was checked by the Till Plain. And hexaploidy was doubtless effected in Tennessee where the diploid and tetraploid races met. The story of *Leavenworthia* is not quite so clear: the genus needs more cytogeographic study. It may be that both the diploid and straight tetraploid races were exterminated during one of the glacial periods. It is important in this regard that the representatives of *L. aurea* in Alabama and in Texas be investigated and with the not unreasonable expectation of discovering one, or both, of the "missing" races. But the races were probably in existence in Tennessee until hexaploidy became fixed (in *L. stylosa* ?); however, it is remembered that hexaploidy might evolve through doubled pollen as well as through diploid-tetraploid crossing, and it is assumed, for example, that hexaploid *S. ternatum* at the southern limit of the species and in association with the tetraploid race so arose (Baldwin 1942). Return northward of *Leavenworthia* on both sides of the Mississippi was through the medium of hexaploid *L. uniflora:* it reached the edge of the Till Plain. That the Nashville Basin is the center of variability for both *Leavenworthia* and *S. pulchellum* probably has an explanation in this: there, because of patchiness of the soil—which is of the type to which these plants are adapted—many separate populations, and of greatly varying sizes, become established; each year the plants, being annuals, died out; mutations and chromosomal changes occurred and became fixed either through adaptive differentiation by selection or through drift by accident, depending on population size; with the passage of time inter-populational migrations took place—and the immigrant annual, as contrasted with perennials, has promise of a good future—and, as soil areas increased, populations merged: these would appear to rank high among the desiderata for rapid and effective evolution. Accidents of

western Missouri into Texas—with a 6-chromosome line, as now expressed in *S. Nevii* Gray ($2n = 12$), with occurrence in Alabama. Further, Baldwin (1944) suggested an amphidiploid origin of diploid *S. Beyrichianum* Masters ($2n = 28$)—known to the writer in Virginia and West Virginia—through *S. Nevii* ($2n = 12$) and diploid *S. ternatum*, Michx. ($2n = 16$), which occurs in southern West Virginia, southwestern Virginia, and eastern Kentucky (Baldwin 1942). The ranges of these sedums were changed under influence of glaciation: the subject will be discussed in detail in a later paper on cytogeography and glaciation.

"ploidy" for these plants were probably not restricted to the Nashville Basin, but, for topographic reasons, such happenings had there better chance of permanent modification of the complex. Intensive study of other elements in the flora of the glades will probably turn up parallels to the basic patterns exhibited by *Leavenworthia* and *S. pulchellum*.

SUMMARY

Leavenworthia seems to consist of four rather well-defined species, of which the geographic ranges and characteristics are given. Three of the species are considered to be hexaploid: $2n = 30$, $n = 15$, and the fourth, *L. aurea*, an aneuploid derivative from tetraploidy: $2n = 22$, $n = 11$. *L. uniflora* is the most clear-cut species and has the greatest distributional area. *L. stylosa* is the most variable species, a condition probably correlated with its self-sterility as contrasted with a high degree of self-fertility in the others, and it has large and showy flowers. *L. torulosa* has the most limited range; it is probably the youngest species and perhaps intergrades somewhat with *L. stylosa*, which, however, is more often confused with *L. aurea*. Because of its southernmost occurrence, disjunct range, and lower chromosome number, *L. aurea* appears to be the oldest member of the genus, and it possibly harbors diploid and tetraploid races: its representatives in Texas have a different aspect from those in Alabama and Tennessee.

The center of variability for *Leavenworthia* is in the Nashville Basin, where all the species occur and to which two of them are in large measure restricted. The genus is one of the characteristic elements of the "glade" flora. The only other complex of the flora that has been studied in cytogeographic detail is *Sedum pulchellum*, with diploid, tetraploid, and hexaploid races: the range of the species and the center of its variability are almost the counterparts of those of *Leavenworthia*. It is suggested that the basic pattern expressed by these complexes—one of the Cruciferae, the other of the Crassulaceae—is a reflection of glacial influence and of the topography of the Nashville Basin, which since mid-Pleistocene has been favorable for the establishment of many populations of varying sizes within which both adaptive differentiation and drift might operate effectively and, because of the annuality of the plants, at a rapid rate. It is expected that other elements of the glade flora have comparable patterns of evolution.

THE BLANDY EXPERIMENTAL FARM
BOYCE, VIRGINIA

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JUNIPERUS VIRGINIANA, J. HORIZONTALIS AND J. SCOPULORUM—IV. HYBRID SWARMS OF J. VIRGINIANA AND J. HORIZONTALIS

NORMAN C. FASSETT

J. virginiana ranges northwestward to southern Maine, northern New York, southern Ontario, northwestern Wisconsin, southern Minnesota, and southwestern North Dakota, while the more northern and local *J. horizontalis* overlaps this range in a few regions; two of these regions have been studied in detail. Except in these regions of overlap, the two species are quite distinct on several characters,[1] of which the four most conveniently dealt with are: (1) the epidermal cells of the leaves of *J. virginiana* average 9–12 μ in width, those of *J. horizontalis* 13–19 μ; (2) the leaf-tips of *J. virginiana* are rarely apiculate, those of *J. horizontalis* always apiculate; (3) *J. virginiana* is an erect tree, *J. horizontalis* a creeping shrub, and (4) in *J. virginiana* not more than a third of the peduncles of the female cones are curved, and in *J. horizontalis* half or more are curved.

TABLE 1. *Twelve individuals of Juniperus from Grand Marsh, Wisconsin*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
10.0	Erect	Acute	.....	*virginiana*
10.0	Erect	Acute	.....	*virginiana*
10.2	Erect	Acute	.....	*virginiana*
12.2	Erect	Acute	.....	*virginiana*
12.7	Erect	Acute	.....	*virginiana*
13.0	Creeping	Apiculate	78	*horizontalis*
13.2	Creeping	Apiculate	.....	*horizontalis*
14.2	Creeping	Apiculate	.....	*horizontalis*
15.0	Creeping	Apiculate	.....	*horizontalis*
16.0	Creeping	Acute	.....	*horizontalis*
17.6	Creeping	Apiculate	82	*horizontalis*
18.0	Creeping	Apiculate	.....	*horizontalis*

On the coast of Maine, and in the Driftless Area of Wisconsin, where the two species overlap in range, a sample has been taken from each individual in a colony,[2] and the character of each individual recorded in tables 1–6.

At Grand Marsh, Wisconsin (Sect. 31, T. 16 N., R. 7 E.), a colony of *Juniperus* on a hillside and sandstone cliffs consists of a number of erect trees and many creeping shrubs. Close examination of the characters of each shows (table 1) the erect trees to be pure *J. virginiana* and the creeping

[1] See Fassett, Bull. Torrey Club **71**: 410–418. 1944.

[2] Much of the necessary travel in this study was financed by the Wisconsin Alumni Research Foundation.

shrubs to be pure (or almost pure) *J. horizontalis*. At this station, then, the two species grow together with little or no interchange of characters. There appear to be internal barriers between the two species.

About a mile east of New Glarus, and conspicuous across the valley from the north side of the town, is a cedar-covered hillside. Only two of the plants are erect (table 2) and these prove to be good *J. virginiana*. The rest of the plants are creeping, looking exactly like *J. horizontalis*, but of these only a few prove to have the other characters of that species. One is *J. horizontalis* in all except its non-apiculate leaf-tips. The rest of the creeping shrubs have epidermal cells of leaves averaging less than 13 μ in width, and leaf-tips not

TABIE 2. *Eighteen individuals of Juniperus from New Glarus, Wisconsin*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
9.7	Erect	Apiculate	.....	*virginiana*
10.0	Creeping	Apiculate	.....	v. *ambigens*
10.8	Creeping	(Juvenile)	.....	v. *ambigens*
11.2	Creeping	(Juvenile)	.....	v. *ambigens*
11.5	Erect	Subapiculate	.....	*virginiana*
12.3	Creeping	Subapiculate	.....	v. *ambigens*
12.3	Creeping	Acute	.....	v. *ambigens*
12.7	Creeping	Apiculate	.....	v. *ambigens*
13.5	Creeping	Apiculate	.....	*horizontalis*
13.8	Creeping	Apiculate	.....	*horizontalis*
14.3	Creeping	Apiculate	.....	*horizontalis*
15.0	Creeping	Apiculate	.....	*horizontalis*
15.3	Creeping	Apiculate	.....	*horizontalis*
15.3	Creeping	Subapiculate	.....	*horizontalis*
15.7	Creeping	Subapiculate	.....	*horizontalis*
15.8	Creeping	Acute	.....	*horizontalis*
17.5	Creeping	Apiculate	.....	*horizontalis*
18.2	Creeping	Apiculate	.....	*horizontalis*

apiculate. At this location none were found fruiting, but similar plants at other places have a great majority of the peduncles straight.

These plants, combining the foliage and fruit of *J. virginiana* with the habit of *J. horizontalis*, are a definite and easily recognized element of the *Juniperus* population in several places where the ranges of the two (presumably parent) species overlap. Of course, its hybrid origin is by no means demonstrated. For convenience, these plants may be called:

J. VIRGINIANA L., var. **ambigens** Fassett, var. nov., caulibus humilis, repentibus vel subascendentibus; foliis pleurumque non apiculatis, epidermidis cellulis latis 5–20 mm., pleurumque 10 mm.; pedicellis pleurumque rectis. MAINE: Needles Eye Island, Thread-of-Life Ledges, Bristol, August 6, 1941, *Fassett 22125* (TYPE in Herb., Univ. of Wis.); exposed sea-cliffs, Small Point, August 4, 1930, *Fassett 10392;* Ogunquit, September 27, 1925, *W. H. Judd* (this and the following collections from Maine are in the Arnold Arboretum); Western Brown Cow, Casco Bay, August 15, 1908, *Norton &*

Chamberlain 1111; Bald Head Cliff, August 9, 1929, *Susan D. McKelvey 3.* WISCONSIN: Sandstone Knob, Prairie du Sac, April 11, 1932, *Fassett 13680* (one trunk erect, with branches trailing); dry crumbling sandstone bluffs, Primrose Twp., Dane County, June 17, 1926, *Fassett 2719;*[3] crumbling sandstone bluff, south of Dane County line, near Belleville, May 26, 1929, *Fassett 8366.*

Several horticultural varieties of *J. virginiana* have been described as low or dwarf forms, but these seem to have no relation to native populations.

At Pine Bluff, Wisconsin, 15 miles west of Madison, a sandstone hillside is covered with cedars, which by their variety of forms present a puzzling aspect. There are erect trees, obviously typical *J. virginiana;* there are

TABLE 3. *Thirteen individuals of Juniperus from Pine Bluff, Wisconsin*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
10.0	Erect	Acute	....	*virginiana*
10.3	Creeping	Acute	0	v. *ambigens*
10.5	Erect	Acute	....	*virginiana*
10.7	Creeping	Apiculate	11	v. *ambigens*
10.8	Ascending	Acute	....	v. *ambigens*
11.0	Ascending	Acute	....	v. *ambigens*
11.5	Creeping	Acute	....	v. *ambigens*
11.7	Ascending	Apiculate	....	v. *ambigens*
11.7	Erect	Subapiculate	9	*virginiana*
12.2	Creeping	Acute	....	v. *ambigens*
13.3	Creeping	Apiculate	....	*horizontalis*
13.5	Creeping	Apiculate	42	*horizontalis*
14.5	Part creeping, part ascending	Acute	33	.....

creeping shrubs, apparently *J. horizontalis;* and with these extremes occur plants with the matted habit and ascending branches of *J. communis* var. *depressa*, some scarcely half a meter in height, others ranging to 2 meters; in a few cases an erect tree has branches which trail out almost enough to simulate *J. horizontalis.* This colony is analyzed in table 3; *J. virginiana* and *J. horizontalis* prove to be present, *J. virginiana* var. *ambigens* is present in its extreme creeping form and grades into a type with somewhat ascending branches.

From its generally disrupted range, we may hypothesize that *J. horizontalis* survived the most recent glaciation in the Driftless Area, and that in post-Wisconsin times *J. virginiana* has migrated into the area from the south. When the two species have met, they have sometimes remained dis-

[3] Some of these collections may be different in different herbaria, since they were collected without a knowledge of the variation in this group and may represent different individuals.

TABLE 4. *Ten individuals of Juniperus from Bald Head Cliff, Maine*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
9.5	Ascending	Acute	.....	v. *ambigens*
9.8	Creeping	Subapiculate	.....	v. *ambigens*
10.2	Creeping	Acute	12	v. *ambigens*
10.3	Ascending	Acute	10	v. *ambigens*
10.8	Ascending	Subapiculate	.....	v. *ambigens*
12.0	Creeping	Subapiculate	59	.....
12.3	Erect	Acute	.....	*virginiana*
13.0	Ascending	Subapiculate	51	.....
13.0	Ascending	Apiculate	24	.....
15.5	Ascending	Subapiculate	.....	.....

tinct (as at Grand Marsh), and sometimes produced a series of hybrids, which may fall into a fairly uniform type (as at New Glarus), or may result in a more or less blending series from one species to the other (as at Pine Bluff). On the coast of Maine, on the other hand, study of colonies from York County to Monhegan Island shows a gradation from a preponderance of *virginiana* characters to one of *horizontalis* characters.

The cedars along the coast of York County, Maine, have been collected by many botanists, with resulting specimens in herbaria labeled "*J. virginiana prostrata*," "*J. horizontalis*" and annotated "*J. virginiana*," "*J. Sabina procumbens?*," "*J. virginiana*, var.," "*J. virginiana* var. *reptans*," "*J. virginiana horizontalis*," "*J. virginiana* var. *Kasteni*," etc.

The colony at Bald Head Cliff has been analyzed (table 4) and shows plants with various combinations of the characters of *J. virginiana* and *J. horizontalis*. While most of the individuals can be fitted into one species or the other, or into *J. virginiana* var. *ambigens*, the last three in table 4

TABLE 5. *Thirteen individuals of Juniperus from Thread-of-Life Ledges, south of Christmas Cove, Maine*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
10.0	Creeping	Apiculate	.....	*v. ambigens*
10.7	Creeping	Acute	37	*v. ambigens*
11.5	Creeping	Acute	34	*v. ambigens*
12.4	Creeping	Apiculate	.....	*v. ambigens*
12.5	Creeping	Apiculate	.....	*v. ambigens*
13.0	Creeping	Apiculate	.....	*horizontalis*
13.0	Creeping	Apiculate	25	*horizontalis*
14.0	Creeping	Acute	35	*horizontalis*
14.5	Creeping	Apiculate	.....	*horizontalis*
14.5	Creeping	Apiculate	15	*horizontalis*
15.0	Creeping	Acute	27	*horizontalis*
15.0	Creeping	Acute	52	*horizontalis*
15.5	Creeping	Acute	.....	*horizontalis*

seem to have the foliage of *J. horizontalis* with an admixture of *J. virginiana* shown by a suberect habit; this combination seems much less common than is that of *virginiana* foliage with *horizontalis* habit. Another tree in table 4 would be *J. virginiana* var. *ambigens*, but has 59 per cent of the peduncles curved.

About 70 miles "down" the coast, on the ledges extending southward from Christmas Cove, Lincoln Co., the rocks are covered with creeping cedars, all of which would, on sight, be pronounced *J. horizontalis*. But a close study of their characters (table 5) shows that nearly half of these shrubs have the foliage of *J. virginiana*. On the basis of the width of epider-

TABLE 6. *Eleven individuals of Juniperus from Monhegan Island, Maine*

Average width of epidermal cells, in micra	Habit	Leaf-tips	Per cent peduncles curved	Identity
14.3	Creeping	Apiculate	75	*horizontalis*
14.3	Creeping	Apiculate	90	*horizontalis*
14.7	Creeping	Subapiculate	85	*horizontalis*
14.7	Creeping	Apiculate	.....	*horizontalis*
15.2	Creeping	Acute	92	*horizontalis*
15.5	Creeping	Apiculate	.....	*horizontalis*
16.0	Creeping	Apiculate	83	*horizontalis*
16.0	Creeping	Apiculate	36	*horizontalis*
16.5	Creeping	Apiculate	90	*horizontalis*
16.8	Creeping	Apiculate	87	*horizontalis*
17.2	Creeping	Apiculate	82	*horizontalis*

mal cells all the individuals in this colony can be placed either in *J. horizontalis* or *J. virginiana* var. *ambigens*, but actually the leaf-tip characters and percentages of hooked peduncles do not correlate very well with other characters; i.e., the *virginiana* and *horizontalis* characters are somewhat mixed up together.

On Monhegan Island (table 6) the population seems to be fairly pure *J. horizontalis*, with only a slight possible indication of influence of *J. virginiana* in the one individual with leaf-tips not apiculate and one with peduncles only 36 per cent hooked.

SUMMARY

Juniperus virginiana and *J. horizontalis* show no intergradation except where their ranges overlap. In the Driftless Area of Wisconsin, the two species grow together, and in the same colony there may or may not be various intermediates. The most common intermediate, described as *J. virginiana* var. *ambigens*, combines the habit of *J. horizontalis* with the foliage and fruit of *J. virginiana*. On the coast of Maine, colonies nearer the range of *J. horizontalis* consist of individuals which are all creeping but which

often show some characters of *J. virginiana*. Colonies nearer the range of *J. virginiana* show all degrees from creeping to erect plants, with other characters of the two species occurring with little or no correlation of specific characters.

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ON BLAKEA AND TOPOBEA

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No group of American melastomes is more easily recognized than the tribe Blakeae, characterized primarily by their axillary flowers each subtended closely by two pairs of decussate bracts, and secondarily by their usually 6-merous flowers with connivent anthers. They may be trees, lianas, or epiphytic trees; they sometimes cover the supporting tree so densely that they cause its death. Markgraf described one species as "frutex scandens suffocator"; in his notes on another he wrote "Das gesammelte Exemplar war 20 m. lang, sein Stützbaum bereits tot."

Blakea and *Topobea* are the two genera of the tribe. In *Blakea* the anthers are very stout, with a prominent connective often prolonged at base into a short conic spur. In *Topobea* the anthers are elongate and narrowly linear, the connective is scarcely thickened, and at base may be prolonged into a short delicate spur. No other character for the separation of the genera is known. Macbride recommends their union into one, and not without reason. Just as many botanists regret the unnecessary segregation of genera with the resulting confusion in literature, so do I regret any tendency to the unnecessary aggregation of genera, especially those which have a long botanical history, are well established in literature, and are capable of exact separation.

Since the genera can be distinguished only when flowers or large flower-buds are available, there has been abundant opportunity to refer herbarium specimens to the wrong genus and, after this preliminary error, to attach erroneous specific names to them or to describe them as "new" species.

The genus *Blakea* dates back to 1756 and the first binomial in the genus was published by Linnaeus for a Jamaican plant. *Topobea* was described by Aublet in 1775 and based on the single species of French Guiana. While a few other species of *Blakea* occur in the West Indies and became known at an early date, most of its species and almost all those of *Topobea* are Amazonian and Andean and were not discovered until comparatively recent times. A century ago eight species were known in both genera; Naudin, having access to collections by Funck & Schlim, Goudot, and Linden, increased the number to seventeen. Triana, largely on the basis of his own collections in the Andes and along the Pacific coast of Colombia, brought the total to 34 by 1871. Cogniaux recognized 55 in 1891, while recent collections in South and Central America have resulted in the description of 33 species of *Blakea* and twelve of *Topobea*, bringing the total to an even hundred. Doubtless some of these names are synonyms; Macbride has made a beginning in the

elimination of superfluous names by calling attention to several in his Flora of Peru.

Notwithstanding the great increase in described species in the last half century there still appear to be many others still unknown to the botanist. Nearly every collecting expedition into the region extending along the Cordilleras from Guatemala to Peru brings back plants which can not be referred to any known species. These always present a serious problem to the taxonomist who approaches his work thoughtfully. A species, in the current opinion of practical taxonomists, is a population of individuals, all much alike in many morphological features but also showing a reasonable degree of variability. In the study of species of the United States, field experience is easily obtained and our herbaria possess such large series that the general range of variability is evident. The species of *Topobea* and *Blakea*, growing in such inaccessible regions, are poorly known in the field and no herbarium has sufficient quantities of material to indicate the variations which may be expected in any one species. Shall we then describe as new those recent collections which can not be referred to known species, or shall we stretch characters inordinately and recognize only a few species of great morphological diversity?

As a general rule, taxonomists tend to follow the former course. Species therefore accumulate until finally the genus is studied comprehensively and necessary reductions are made.

Nevertheless, certain discoveries indicate that more valid species exist than the 55 recognized by Cogniaux. For example, *B. bracteata*, which I described in 1932, represented an entirely new type of structure for the genus, and was followed by the description of two or three more of the same general type from the rain-forests of upper Amazonia. My *B. calycosa*, with foliaceous appendages on the sepals, and my *B. glandulosa*, with glandular pubescence, also represent entirely new types.

There has been only one attempt, that of Cogniaux in 1891, to provide a key to all the known species and this proves to be largely artificial, species which are obviously much alike often being widely separated on some trivial distinction. Macbride provided two keys for the Peruvian species, which form a small minority of the total, and these are also obviously artificial.

The coastal forests of western Colombia and the adjacent slopes of the Cordillera Occidental have more species of the two genera than any other region and may well be regarded as their center of distribution. Among the recent collections of Dr. Cuatrecasas in western Colombia is a remarkably fine series of these interesting and often beautiful plants, mostly in full bloom so that they can be assigned to the proper genus. These form the basis of the remarks which follow. Cited collections are in the Britton Herbarium of the New York Botanical Garden.

BLAKEA ANDREANA Cogn. Although the outer bracts of this species are united to the middle, as shown by the type and clearly stated in the original description, Cogniaux placed it in the section *Eublakea*, characterized by bracts free or "rarius connatis." It seems closely related to *B. intercepta* and *B. brunnea*, which I have recently described from Costa Rica, and also to two undescribed species of Colombia. All have exceptionally large flowers with large coriaceous bracts nearly or quite as long as the obscurely lobed or truncate calyx. The Colombian species may be distinguished as follows:

Outer bracts free, ovate, acuminate ..... *B. clusiifolia.*
Outer bracts connate at base, rotund.
Leaves elliptic, abruptly acuminate, furfuraceous on the primary veins beneath; plants of the Cordillera Oriental ..... *B. Andreana.*
Leaves obovate, broadly rounded to a short apiculum, glabrous beneath; plants of the Cordillera Occidental ..... *B. Cuatrecasii.*

Blakea clusiifolia Gleason, sp. nov. Arbor 6–9 m. alta ubique glabra, ramis subteretibus. Petioli validi, 1–2 cm. longi; laminae subcoriaceae carnosae obovatae, usque ad 13 cm. longae 8 cm. latae, apice late rotundatae vel subretusae ad cuspidem linearem 5–8 mm. longam, integrae, basi cuneatae, 3-nerviae vel sub-3-pli-nerviae, jugo marginali neglecto, venis secundariis obscuris ca. 1.5 mm. distantibus, sub angulo ca. 70° adscendentibus. Pedunculi solitarii, 2.5 cm. longi, ad apicem valde incrassati. Bracteae exteriores late ovatae, 25 mm. longae, acuminatae, quam interioribus obtusis duplo longiores. Flores ignoti.

TYPE: *Killip & Smith 15295*, from Mesa de los Santos, Dept. Santander, Colombia, alt. 1500 m.

BLAKEA ANDREANA Cogn. Known to me by the type collection of André, by *Killip & Smith 20197*, from Dept. Norte de Santander, alt. 2100–2400 m., and by *Lawrance 153*, from Dept. Boyaca, alt. 2300 m.

Blakea Cuatrecasii Gleason, sp. nov. Arbor epiphytica glabra, ramis subteretibus. Petioli validi, 8–12 mm. longi. Laminae subcoriaceae carnosae, obovatae, superne late rotundatae ad cuspidem triangularem 3 mm. longam, integrae, basi cuneatae, trinerviae, jugo marginali neglecto, venis secundariis obscuris, sub angulo ca. 75° adscendentibus. Pedunculi solitarii validi suberecti, usque ad 4 cm. longi. Bracteae exteriores coriaceae, 2.5 mm. connatae, rotundae, 18 mm. longae lataeque; interiores oblatae, coriaceae, 15 mm. longae, 19 mm. latae. Hypanthium coriaceum, hemisphaericum, ad oram 15 mm. latum. Calyx patulus integer 5 mm. latus. Petala obliqua obovata, alba venis roseis, 35 mm. longa 20 mm. lata. Filamenta 12.5 mm. longa. Antherae ovoideae, 11 mm. longae, medio ad filamentum affixae, poris 2 terminalibus dehiscentes; connectivum alte elevatum in carinam dorsalem, ecalcaratum. Stylus columnaris 12 mm. longus; stigma punctiforme.

TYPE: *Cuatrecasas 15180*, from the Cordillera Occidental, Dept. del Valle, alt. 900–1180 m. His number *14946*, from the same locality, is identical, except the petals are described as red ("rojos"). I can detect no differences of taxonomic importance in his numbers *16393* and *16638*, although they were collected at an altitude of only 5–50 m.; the petals of the former are described as "rojos exteriormente, rosado claros interiormente," those

of the latter as "blanco rosados." I also refer to this species *Killip 7914*, from the Micay Valley, Dept. El Cauca, alt. 1800–1900 m., originally reported as *B. Pyxidanthus* Triana.

Blakea calyptrata Gleason, sp. nov. Arbuscula epiphytica, ramis teretibus tomentosulis. Petioli validi, 3–5 cm. longi, tomentosuli. Laminae subcoriaceae, ellipticae, usque ad 18 cm. longae 11 cm. latae, abrupte et breviter apiculatae, integrae, basi cuneatae vel obtusae, 5-plinerviae jugo marginali neglecto, supra glabrae subnitentes, subtus cinereo-stellato-tomentosae; venae secundariae 3–5 mm. distantes, sub angulo 80° adscendentes. Flores 2–5 axillares; pedunculi validi, superne incrassati, 1–2 cm. longi, dense tomentosi. Bracteae conformes distinctae, spathulatae, ca. 17 mm. longae, revolutae, tomentosae. Calyx calyptriformis, conico-ovoideus, ad torum circumscissilis, cum hypanthio cinereo-tomentosus, 5 mm. altus. Petala roseo-rubra, ut videtur obovata, certe 2 cm. longa. Filamenta ca. 5 mm. longa. Antherae ovatae, 6 mm. longae, poris binis terminalibus dehiscentes; connectivum in carinam angustam elevatum, basi infra thecas 2 mm. productum.

TYPE: *Cuatrecasas 14945*, collected in woods at Piedra de Moler, Dept. del Valle, alt. 900–1180 m.; *Cuatrecasas 15535*, from the same general region, is the same; also collected by Lehmann at Mesopotamia in Dept. Antioquia. A calyptriform calyx is hitherto unknown in the genus and the spatulate bracts are equally unexpected. There is no doubt that the plant belongs to the genus *Blakea;* in fact, the Lehmann collection was given a manuscript name in this genus by Cogniaux years ago.

In *Cuatrecasas 17524* we find the same calyptriform calyx, as indicated in its flowering condition by the truncate calyx. It agrees with the plants described above except in some minor matters of dimensions which are well within the limits of expected variability, and in its bracts. These are so different from those of the type that I propose a new variety:

BLAKEA CALYPTRATA var. **latior** Gleason, var. nov. Bracteae exteriores ovato-lanceolatae 8.3 mm. longae, 4.3 mm. latae, interiores rotundae, ca. 8 mm. longae lataeque.

TYPE: *Cuatrecasas 17524*, from the Pacific coast of Dept. del Valle, 5–80 m. alt.

BLAKEA PODAGRICA Triana. *Cuatrecasas 14420*, western slope of the Cordillera Occidental, alt. 350–450 m.; *16530*, *14315*, *16893*, *16992*, *17583* from the Choco Region. Bracts pale, herbaceous, conspicuously veined, ovate or ovate-lanceolate, up to 2 cm. long and much exceeding the cup-shaped hypanthium; sepals reflexed, triangular, acuminate. Every plant shows several of the upper internodes clavately thickened into formicaria.

BLAKEA SUBCONNATA Berg is known to me only from Ecuador. It is characterized by large, separate, herbaceous, acuminate bracts, and by the singular anastomose venation of the calyx-tube, a character not readily observed except by transmitted light. The petioles are conspicuously winged with the sides turned up, forming a deep channel. Two specimens from Colombia agree with these features, except that the bracts are round-ovate and very obtuse; they may be segregated as a variety:

BLAKEA SUBCONNATA var. **obtusa** Gleason, var. nov. Bracteae late rotundato-ovatae, obtusae.

TYPE: *Cuatrecasas 15644*, collected on the western slope of the Cordillera Occidental, Dept. del Valle, alt. 1400 m.; *Cuatrecasas 14988*, from the same region, is identical. His *17576* is obviously also the same, although collected at an altitude of 5–80 m.

Blakea venosa Gleason, sp. nov. Liana magna, ramis juvenilibus subteretibus sordide furfuraceo-tomentosis, pilis partim brevibus substellatis partim elongatis barbellatis. Petioli 1–2 cm. longi, graciles, non alati, supra canaliculati, furfuracei. Laminae tenues, elliptico-oblongae vel paullo obovatae, usque ad 12 cm. longae 6.5 cm. latae, superne abrupte rotundatae ad apiculum triangularem 5–8 mm. longum, basi late cuneatae vel obtusae, 5-plinerviae jugo marginali neglecto, supra glabrae subnitentes, subtus ad paginam glabrae ad venas sparse furfuraceo-pubescentes; venae secundariae fere horizontales 1 mm. distantes. Pedunculi solitarii vel bini, 1–2 cm. longi, dense ferrugineo-tomentosi, pilis barbellatis. Bracteae exteriores ellipticae, ca. 22 mm. longae 19 mm. latae, distinctae, herbaceae, obtusae, minute apiculatae, multivenulosae, primo basi tenuiter furfuraceae at sparse strigosae, mox glabrescentes; interiores rotundae, ca. 22 mm. longae 25 mm. latae, glabrae. Hypanthium carnosum, hemisphaericum, glabrum, 6 mm. longum, ad oram 12 mm. latum. Calycis tubus patens, tenuis, 1.8 mm. latus; sepala ca. 5 mm. longa, late triangularia, venis reticulatis percursa, vena media in carinam angustam elevata. Petala rosea, obovata, 22 mm. longa. Antherae oblongae, 6 mm. longae, ut videtur ecalcaratae. Ovarium summo truncato-conicum, minute dentatum. Stylus 12 mm. longus; stigma punctiforme.

TYPE: *Cuatrecasas 14171*, collected at Guayabal on the Pacific coast, Dept. Cauca, alt. 5–20 m. The large herbaceous bracts completely concealing the calyx and the strongly anastomosing veins of the sepals show its close relationship to *B. subconnata*, from which it is distinguished by the pubescent stems, petioles, and peduncles, and the wingless petioles. Flowers are dissected with difficulty, as in *B. subconnata*.

Blakea paleacea Gleason, sp. nov. Petioli certe 8 cm. longi, subglabri. Lamina crassa subcoriacea late ovato-cordata 44 cm. longa 37 cm. lata, apice obtusa, apiculo lineari 2 cm. longo, basi late cordata, supra glabra, subtus ad paginam glabra opaca, ad venas primarias paleacea. Inflorescentia congesta 10–20-flora; pedunculi densissime paleacei usque ad 4 cm. longi. Bracteae distinctae herbaceae multinerviae, exteriores ovato-lanceolatae 23 mm. longae, longe acuminatae, apicem versus ad costam dense paleaceae; interiores ovatae 18 mm. longae, ad apicem rugosae. Hypanthium cum calyce molliter carnosum glabrum 6 mm. longum; sepala late triangularia 3 mm. lata 0.7 mm. longa, venis anastomosantibus notata. Stamina immatura *Blakeae*.

TYPE: *Cuatrecasas 17271*, collected at Quebrada de Ordóñez, on the Pacific coast of El Valle, alt. 5 m. Its relation to *B. subconnata* is shown by its general habit, its sepals with anastomosing veins, and the general characters of its bracts; like that species it becomes very soft after boiling and dissection is difficult. It differs from both in its huge cordate leaves, its greatly elongate bracts, and its pubescence, which consists of stout flattened scales up to 2 mm. long which quickly break up into a mass of fibers. The collector's notes read "Varas 1 m. Cáliz verdoso amarillento. Corola roja."

Blakea platypoda Gleason, sp. nov. Arbor glabra, ramis ultimis crassis subteretibus. Petioli validi 2.5–4 cm. lati, late alati usque 2 cm. lati. Laminae subcoriaceae nitentes obovato-oblongae, usque ad 22 cm. longae 11 cm. latae, superne obtusae ad apiculum triangularem 8 mm. longum, basi obtusae, 3-nerviae jugo marginali neglecto; venae secundariae obscurae, 1.5 mm. distantes, sub angulo ca. 80° adscendentes. Pedunculi 1–3 in quaque axilla, usque ad 4 cm. longi. Bracteae subherbaceae distinctae subrotundae concavae, 20–22 mm. longae lataeque, obtusae, exteriores breviter apiculatae. Hypanthium hemisphaericum 7.5 mm. longum 12-costatum. Calycis tubus 3 mm. latum; sepala late rotundata e sinubus rotundatis, 1 mm. longa, venis anastomosantibus percursa, dente exteriore brevi subapicali notata. Stamina (jam immatura) *Blakeae;* antherae jam 8 mm. longae, ut videtur ecalcarata. Ovarium summo non productum.

TYPE: *Cuatrecasas 17027*, collected at Barco, on the Pacific coast of El Valle, alt. 5–80 m. This is a fourth member of the *subconnata* species group, as evidenced by the enlarged petioles, spurless anthers, veiny sepals, general habit, and the peculiar difficulty of dissection. *Cuatrecasas 17266E* is identical and has larger leaves up to 23 by 16.5 cm. The four species may be distinguished as follows:

Pubescence none, or obscure and furfuraceous.
- Bracts short-acuminate to obtuse; leaves thin, opaque; petioles up to 1 cm. wide ..... *B. subconnata.*
- Bracts obtuse or shortly apiculate, subcoriaceous; leaves firm, shining; petioles up to 2 cm. wide ..... *B. platypoda.*

Pubescence abundant, of long barbellate or fissile hairs.
- Leaves obovate-oblong, 5-pli-nerved; bracts elliptic, obtuse ..... *B. venosa.*
- Leaves broadly cordate, 9-nerved; bracts ovate to lanceolate, long-acuminate ..... *B. paleacea.*

Topobea alternifolia was described by me in 1925, based on a specimen which showed foliage, bracts, and sepals, but not petals or stamens. It was collected again by Killip & Garcia, no. *33415*, at the same locality in 1939. Now we have excellent flowering material in *Cuatrecasas 16585* which not only permits me to complete the specific description but also requires me to transfer the species to *Blakea.*

Blakea alternifolia Gleason, comb. nov. *Topobea alternifolia* Gleason, Bull. Torrey Club **52**: 459. 1925. Petals obovate-oblong, 5 mm. long, rounded at the summit. Anthers very stout, 2 mm. long, flat and broad at the apex, opening by a dorso-terminal pore; connective much thickened toward the truncate base, not prolonged below the thecae. Sepals not triangular, as originally described, but oblate-rotund above a constricted base.

Blakea stellaris Gleason, sp. nov. Liana lignosa magna, ramis juvenilibus sordide furfuraceis subteretibus. Petioli 3–10 mm. longi furfuracei. Laminae late ovato-ellipticae, usque ad 10 cm. longae 7 cm. latae, superne rotundatae ad apicem breviter cuspidatum, basi cordatae, 5-nerviae, jugo marginali obscuro neglecto, supra glabrae opacae, subtus arctissime cinereo-tomentosae; venae secundariae 2–4 mm. distantes, sub angulo ca. 75° adscendentes. Flores solitarii vel bini, sessiles. Bracteae distinctae, coriaceae, ovato-lanceolatae, 7 mm. longae, 3.5–4 mm. latae, subacutae, dense tomentosae. Hypanthium campanulatum, 5 mm. longum, glabrum. Calycis tomentosi

tubus 2 mm. longus, intus ad torum dense longeque villosus; sepala triangulares, 5.4 mm. longa, acuta, extus dense intus parce tomentosa, matura stellatim patentia. Petala purpurea coriacea oblonga, 10 mm. longa 4 mm. lata, obtusa. Antherae oblongae 4 mm. longae, poris 2 dorso-terminalibus dehiscentes; connectivum in carinam elevatum, supra basin calcare dorsali conico 0.5 mm. longo ornatum. Ovarium semi-inferum summo dense pilosum.

TYPE: *Cuatrecasas 16129*, from Peña de Candelario, on the coast of El Valle, alt. 10 m. The plant is apparently related to the Peruvian *B. sessiliflora* Naud., which also has sessile flowers with well developed sepals. In this Peruvian species the petiole is much longer, the leaf-base is acute, the leaf-surface is glabrate, the bracts are smooth, and the sepals are much shorter. *Cuatrecasas 16620* and *17189* are very similar, but deviate from the type in larger, distinctly oblong leaves broadly rounded or somewhat retuse to the apiculum and denser and shaggier tomentum. They are nevertheless referred to the same species. Sessile flowers are certainly unusual in the genus.

Blakea pilosa Gleason, sp. nov. Liana lignosa; rami superiores densissime pilosi, pilis adpressis usque 8 mm. longis, ad nodos densissime setosi, setis erectis usque 15 mm. longis. Petioli ca. 1 cm. longi, validi, subtus pilosi sicut caules, supra glabri. Laminae anguste oblongo-lanceolatae, 25–30 cm. longae, 8 cm. latae, acuminatae, integrae, basi cuneatae, 3-nerviae jugo marginali neglecto, supra glabrae opacae, subtus ad venas primarias densissime adpresso-pilosae, ad venas secundarias tomentosae, ad paginam glabrae; venae secundariae ca. 2 mm. distantes, sub angulo ca. 80° adscendentes. Flores 6-meri, 2 vel 3 fasciculati in quaque axilla; pedunculi 5–8 mm. longi setis longis subtenti. Bracteae omnes distinctae pilis longis subtentae, exteriores coriaceae rotundae, 9–10 mm. longae 7–8 mm. latae, interiores subrotundae 12 mm. longae 15 mm. latae. Hypanthium hemisphaericum carnosum glabrum, 5 mm. longum, pilis usque ad 8 mm. longis subtentum. Calycis tubus non evolutus; sepala ad torum distincta, late reniformia, basi imbricata, ca. 3.5 mm. longa, 7 mm. lata, dense ciliata. Petala rosea oblongo-lanceolata glabra, 17–19 mm. longa 7 mm. lata, subacuta. Filamenta 4.5 mm. longa 1.8 mm. lata. Antherae cohaerentes oblongae, 4.8 mm. longae, poris 2 terminalibus dehiscentes; connectivum in carinam dorsalem incrassatum, basi non productum subcordatum. Ovarium summo truncato-conicum glabrum; stylus rectus 10.5 mm. longus; stigma truncatum.

TYPE: *Cuatrecasas 16532*, collected at La Trojita, in the Choco region, alt. 5–50 m. This plant represents another completely new type of structure in the genus. Its stems covered by a mass of fibers, its strongly setose nodes, even including those floral nodes bearing the bracts and flowers, its reniform, ciliate, imbricate sepals, and its narrow petals are all equally distinctive. There is no other known species with which it may be compared.

Blakea florifera Gleason, sp. nov. Frutex robustus 2 m. altus, "caule quadrangulari" (mihi ignoto). Petiolus validus 19 cm. longus, dense setosus, pilis usque ad 8 mm. longis basi 1 mm. crassis. Lamina herbacea, late ovata, 44 cm. longa 33 cm. lata, abrupte acuminata, basi late rotundata, supra glabra, subtus ad paginam glabra ad venas primarias basi hispida, 9-nervia; venae secundariae ca. 5 mm. distantes. Flores 6-meri, ca. 50 in quaque axilla; pedunculi furfuracei usque ad 4 cm. longi. Bracteae distinctae membranaceae venosae, obovato-oblongae, 11 mm. longae, apice late rotundatae,

glabrae vel fere glabrae. Hypanthium cum calyce late poculiforme, ca. 10 mm. latum, glabrum, fere truncatum; sepala ad dentes 6 triangulares 0.3 mm. longos reducta. Petala rosea, obovato-rotunda, certe 8 mm. longa.

TYPE: *Cuatrecasas 15116*, from Piedra de Moler, Cordillera Occidental, Dept. del Valle, alt. 900–1180 m. The stamens could not be dissected clearly, but seem to indicate the genus *Blakea* with little doubt. The specimen consists of a single leaf, as described above, and a longitudinal section of a part of an internode, showing a single fascicle of flowers. The great number of long-pedunculed flowers is distinctive, as well as the huge broad leaves and setose petioles.

Topobea pubescens Gleason, sp. nov. Arbuscula epiphytica, ramis supremis subquadrangularibus, ad nodos incrassatis, dense ferrugineo-pubescentibus. Petioli validi, 2–4 cm. longi, dense pubescentes. Laminae membranaceae, late ovatae, usque ad 23 cm. longae 18 cm. latae, abrupte acuminatae in apiculum triangularem 1 cm. longum, leviter sinuato-denticulatae, basi late rotundatae cordulatae, 5-nerviae jugis binis submarginalibus neglectis, supra glabrae punctículatae, subtus ad venas densiuscule pubescentes, ad paginam molliter stellatae; venae secundariae horizontaliter patentes 2–4 mm. distantes. Flores 2–4 in fasciculis in axillis foliorum vivorum et delapsorum; pedunculi usque ad 5 mm. longi, dense pubescentes. Bracteae exteriores 1 mm. connatae, late rotundo-ovatae vel paullo obovatae, 9–10 mm. longae 7–8 mm. latae, apiculo minuto triangulari, subtomentosae; interiores connatae 1.5 mm., rotundae, ca. 8 mm. longae lataeque. Hypanthium obconicum, ca. 6 mm. longum, parce pubescens. Calycis tubus 2.8 mm. longus, sicut hypanthium pubescens; sepala breviter triangularia, 1.1 mm. longa. Petala roseo-purpurea, inaequaliter obovata, 16 mm. longa 10 mm. lata. Filamenta tenues, 10 mm. longa; antherae lineares, 10 mm. longae, poro unico dehiscentes; connectivum vix elevatum in carinam dorsalem, basi in calcar lineare 2.8 mm. longum productum. Ovarium semi-inferum, superne productum in coronam 4 mm. longam apice in lobos filiformes 1 mm. longos fissam.

TYPE: *Cuatrecasas 16784*, collected between La Esperanza and Bellavista, Dept. del Valle, alt. 5–10 m. It is apparently related to *T. superba* Triana with similarly large leaves and bracts but nearly glabrous. A similar corona on the ovary is characteristic of *T. stephanochaeta* Naud., which is a glabrous plant with much smaller flowers and proportionately smaller bracts.

TOPOBEA FLORIBUNDA Gleason. I refer here *Cuatrecasas 16388*, collected in the same general region as the type. It differs from the type in its outer bracts rotund instead of acuminate, and in its leaves stellate-pubescent on the surface beneath, instead of glabrous and shining. The two come from the same general region in the Choco.

Topobea longisepala Gleason, sp. nov. Frutex epiphyticus, ramis ultimis teretibus arcte ferrugineo-tomentosis. Petioli 12–15 mm. longi tomentosi. Laminae chartaceae ellipticae usque ad 25 cm. longae 10 cm. latae, apice subiter in apiculum 12–15 mm. longum contractae, basi rotundatae, 5-nerviae vel sub-5-pli-nerviae jugo marginali excepto, subtus primum dense stellatae ad paginam, mox glabrescentes, ad costas tomentosae, supra primum stellatae mox glabrae; venae secundariae 2–4 mm. distantes. Pedunculi 1–3 in quaque axilla, 1 mm. longi; bracteolae 2 mm. longae, bracteis conformes. Bracteae distinctae coriaceae tomentosae rotundae vel late obovatae ca. 3 mm. longae

lataeque. Hypanthium campanulatum 2.5 mm. longum tomentosum. Calycis tubus 0.8 mm. longus; sepala adscendentia oblonga 3.5 mm. longa tomentosa. Petala ochraceo-viridia obovato-oblonga 5.5 mm. longa acuta. Filamenta gracilia 2.5 mm. longa; antherae subulatae 3 mm. longae; connectivum vix elevatum basi calcare minuto ornatum. Ovarium summo 1.3 mm. productum; stylus 3 mm. longus ad stigma punctiforme angustatus.

TYPE: *Cuatrecasas 16975*, collected at Barco, on the Pacific coast of El Valle, alt. 5–80 m. The small, almost sessile flowers densely covered with brown tomentum and with elongate sepals differentiate it from every species known to me.

Topobea barbata Gleason, sp. nov. Liana lignosa epiphytica. Petioli validi glabri 25–35 mm. longi. Laminae cariaceae obovatae, usque ad 15 cm. longae 10 cm. latae, superne late rotundatae vel retusae ad apiculum triangularem 2–4 mm. longum, basi late cuneatae, 5-nerviae, fere 5-pli-nerviae, jugo marginali neglecto, jugo exteriore submarginali, supra glabrae nitentes, subtus glabrae opacae, copiose nigro-punctatae, in axillis venarum 3 mediarum dense longeque barbellatae, pilis ca. 2 mm. longis; venae secundariae supra obscurae subtus vix prominulae, 1–1.5 mm. distantes, sub angulo 80° orientes. Pedunculi 1–3 in quaque axilla, usque ad 15 mm. longi, glabri, superne incrassati. Bracteae brunneae glabrae coriaceae, exteriores 5.5 mm. longae 3.3 mm. connatae; interiores liberae, late oblatae, 7 mm. longae, una alteram basi fere obtegens. Hypanthium campanulatum coriaceum glabrum 6.5 mm. longum. Calycis coriacei tubus 3.7 mm. longus; sepala depresso-triangularia 1.1 mm. longa minute apiculata. Petala rosea rhomboidea 16 mm. longa. Filamenta 7.5 mm. longa; antherae crasse subulatae 6.4 mm. longae, thecis truncatis bilobulatis poris 2 terminalibus dehiscentibus, basi infra insertionem filamenti productis; connectivum non incrassatum basi in calcar conicum retrorsum 1.2 mm. longum productum. Ovarium semi-inferum, summo conicum; stylus 12 mm. longus; stigma punctiforme.

TYPE: *Cuatrecasas 17215*, collected at Barco, on the Pacific coast of Dept. El Valle, alt. 5–80 m. No described species of the genus has tufts of hairs in the vein-axils or similarly retuse leaves.

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FICUS ALTISSIMA

MARY F. BARRETT

The objects of this paper are to differentiate between *Ficus bengalensis* L. and *F. altissima* Blume, two occasionally confused species which may show the banyan habit; to summarize the characters of *F. altissima*, and to examine its alleged synonyms and variety.

FICUS BENGALENSIS[1] L. Sp. Pl. 1059. 1753. *F. bengalensis* is believed to have been the giant species of *Ficus* seen in the Punjab, India, in 326 B.C. by the army of Alexander the Great. It has been known also as *F. indica* L. Some of its characters are almost the same as those of *F. altissima*. Differences are: crown diameter of largest trees 90–180 m., number of potential secondary trunks to 4350; petioles always hairy; blades broad-ovate or ovate-rotund; base rounded or subcordate; apex usually gradually narrowed and obtuse, rarely rounded and very short-acuminate; surfaces dull and velvety, the upper rarely becoming bare, tan or greenish-tan when dry, not papillate; 2–4 sets of apparently basal veins, 5–7 sets of secondary veins whose upper angle at midrib is about 40°; a conspicuous gland near the base of the blade; flowers said by King to have a perianth of four separate pieces; figs globose, becoming depressed at the apex, to 2 cm. in diameter, red, velvety with short white hairs; basal bracts 3, white-velvety, each about 7–8 mm. long, separate but overlapping, making a base about 12 mm. in diameter; native distribution uncertain because of extensive cultivation of the species; probably from the Indian states just south of the Himalayas, east to the head of the Bay of Bengal, south to Central India, along the west coast to Goa and Malabar.

FICUS ALTISSIMA Blume, Bijdr. 444. 1825. ? *Varinga latifolia* Rumph. Herb. Amb. **3**: 127. *pl. 84(2)*. 1743. *F. laccifera* Roxb. Hort. Beng. 66. 1814. *Nomen nudum*. Fl. Ind. **3**: 545. 1832. *F. peguensis* Buch.-Ham. ex Wall. Cat. no. 4560 C *in part*. 1831. *Nomen nudum*. *F. varenga* Buch.-Ham. ex Wall. Cat. no. 4560 I *in part*. 1831. *Nomen nudum*. *Urostigma lacciferum* (Roxb.) Miq. Hook. London Jour. Bot. **6**: 575. 1847. *U. altissimum* (Blume) Miq. ex Zoll. Syst. Verz. **2**: 90. 1854. *F. altissima* var. *laccifera* (Roxb.) Trim. Syst. Cat. Ceylon 84. 1885. *F. altissima* forma *laccifera* (Roxb.) King ex Koord. & Val. Booms. Java **11**: 87. 1906.

Independent or an epiphytic strangler; shrub, or tree 10–25 m., rarely to 40 m. high, crown diameter to 40 m. or more, a few secondary trunks and aerial rootlets; trunk diameter 1–5 m., to 10 m., sinuous and becoming hollow if made by strangling roots, basal buttresses and prop roots present; trunk

[1] This name was spelled *benghalensis* by Linnaeus, as it was an earlier polynomial by another author. The *h* seems to have been retained in texts until about 1860, but since then has usually been omitted. That there was no reason for its presence is shown by early references to Bengal, and by the title of Roxburgh's *Hortus bengalensis*, published in 1814. Linnaeus' spelling is therefore treated as an orthographic error.

bark and branches usually gray, smooth; twigs stout, gray-green to tan, white-hairy to bare; terminal buds usually 2–3.5 cm., rarely to 5 cm. long, conical, white -hairy to bare, deciduous; petioles usually 3–5 cm. long; blades usually ovate, sometimes elliptical, largest 14–17 × 8–12 cm., rarely to 30 × 21 cm.; base rounded, rarely narrowed; apex rounded and abruptly acuminate,

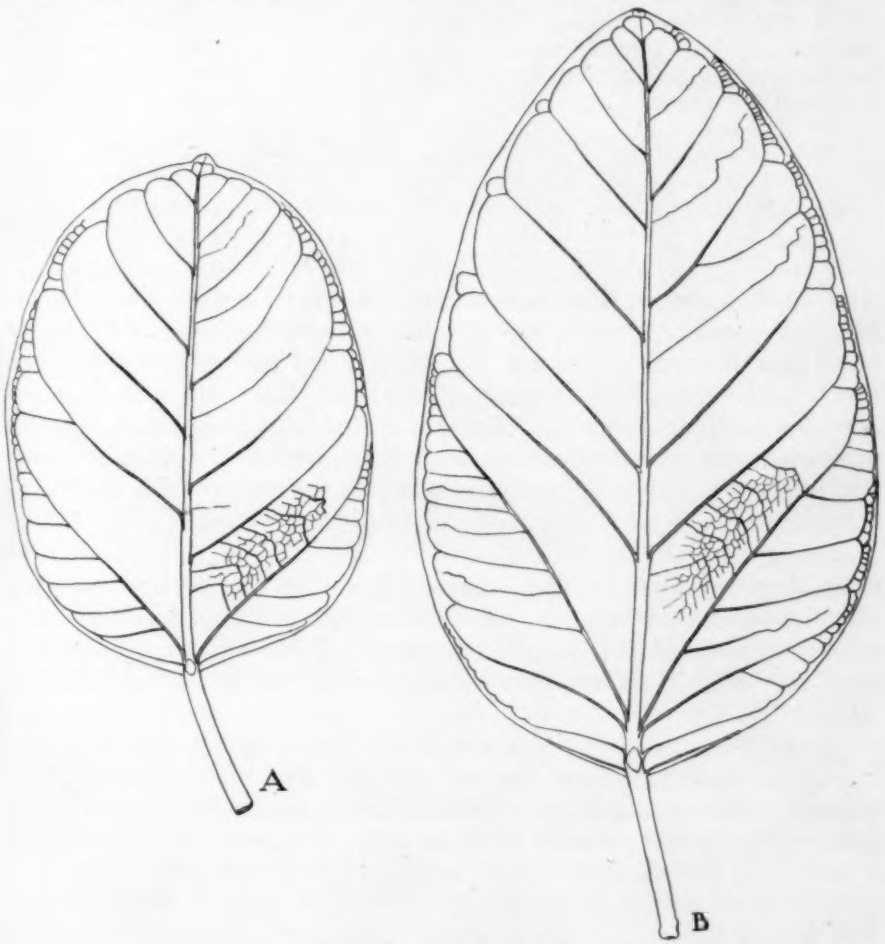

FIG. 1. Under surface of leaves of *Ficus altissima* (A) and *Ficus bengalensis* (B), showing differences in shape, apex and basal veins. Relative size is not significant. × ½. Drawings by J. Kenneth Sanders.

rarely narrowed and obtuse, the acumen short and thick; upper surface of the blade glossy, dark green with lighter colored veins, papillate; lower surface paler; blades tobacco-brown, leathery, thick and stiff when dry; a pair of basal veins making a conspicuous V of about 80°, usually a smaller pair below; 6–8 sets of secondary veins, their upper angle about 50°, forking and

uniting to form an intramarginal vein; sometimes a discontinuous tertiary vein; reticulum and checkered background present; basal gland scarcely visible; male flowers said by King to have a pedicel and 4 perianth-parts, the stamen subsessile; perianth of gall and female flowers gamophyllous, deeply 4-cleft, the styles lateral and elongate, the gall flowers pedicelled or sessile, the female flowers usually sessile; figs on leafy twigs, axillary, sessile, ovoid, 2–3 × 1.5–2 cm., green becoming yellow or orange, rarely red, often sparsely papillate, velvety to bare; basal bracts 3, white-hairy, united, at first forming a calyptriform cup around the fig, later breaking off and leaving a thick pad 7–10 mm. across.

TYPE: Java.

Distribution: Malay Archipelago and States, Andamans, Burma, states south of the Himalayas to Northwest India, south to Central and perhaps to South India, Philippines, Indo-China, South China. Widely planted.

ALLEGED SYNONYMS OF FICUS ALTISSIMA

VARINGA LATIFOLIA Rumph. Herb. Amb. **3**: 127. *pl. 84(2)*. 1743. Miquel (Fl. Ind. Bat. **1**[2]: 349. 1859) thought that this tree was near his *Urostigma altissimum*. Koorders & Valeton (Booms. Java **11**: 108. 1906) saw a resemblance between the figs in Rumphius' plate and those of *F. altissima*, and Merrill (Philippine Bur. Sci. Publ. No. 9: 194. 1917) has stated that the description represents that species or one very closely allied to it. The location of the type, Amboina, probably is within the range of distribution of *F. altissima*.

Varinga latifolia has been allocated to five different species, partly because of the variety of synonyms cited by Rumphius, and partly on account of its insufficient description and probably inaccurate plate. The native names are not helpful: *Waringin*, the original of *Varinga*, is applied also to other species of *Ficus*, and another local name is merely a translation of *latifolia*.

According to the description and the plate the habit is that of a large epiphytic strangler. The leaf is ovate with narrowed base and apex. There is a very short acumen. There are about 7 sets of secondary veins, all at the same angle. The figs measure about 2.5 × 1.3 cm. (actual size), turn from yellow to red to black as they ripen, and are borne in a raceme.

Although such leaves are not typical, similar ones of *F. altissima* have been seen by the writer in the herbaria of the New York Botanical Garden and the Arnold Arboretum. The figs of this species may become black as they decay, although dried ones are reddish-brown. The racemous fruit cluster can not be reconciled with that of *F. altissima*, and, in fact, is rarely found among species of *Ficus*. Nevertheless *Varinga latifolia* is probably the same as Blume's species.

FICUS LACCIFERA Roxb. Roxburgh gave this name to specimens collected in 1811 by M. R. Smith at "Silhet" (Sylhet in Assam), India. From that

time until 1885 the species was reported from the northeastern Himalayas as far south as southern India and Ceylon, and also from Burma and the Andaman Islands; while *F. altissima* apparently was mentioned only from the Netherlands East Indies. In 1885 Trimen declared that *Urostigma lacciferum* listed by Thwaites (Enum. Pl. Zeyl. 265. 1864) from Ceylon was, in part, var. *laccifera* of *F. altissima*. But Trimen (Handb. Fl. Ceylon **4**: 87. 1898) cited *U. lacciferum* as a synonym and not a variety, adding that it was doubtful whether it was wild in Ceylon. The text of King (1887) calls *laccifera* a form, although his plates use the labels "*F. laccifera*" and "var. *laccifera*." Gagnepain (*in* Lecomte, Fl. Gén. Indo-Chine **5**: 781. 1928) retains the name as a variety.

Roxburgh's description of *F. laccifera* differs from *F. altissima* only in glabrous stipules and glabrous figs the size of a gooseberry. The characters of the figs were ignored or changed by some later observers, but the bare stipules were frequently reported. This constitutes a slight, but in the opinion of the writer an insufficient justification for the separation of *laccifera* into a variety or form. King's statement that it is a northern form with larger, thinner leaves than those of *F. altissima* is nullified by distribution reports by Beddome (Fl. Sylv. S. India **2**: 223. 1874), Brandis (For. Fl. India 418. 1874), and others; and by specimens of large leaves from trees with hairy stipules, such as have been found by the writer in Florida.

F. PEQUENSIS and F. VARENGA Buch.-Ham., both ex Wall. Ct. 1831. *Nomina nuda* were not placed by Wallich under no. 4559, *F. laccifera* Roxb.; but under no. 4560, *F. indica* Roxb. (*F. bengalensis* L.). Haines (Bot. Bihar & Orissa pt. 6. app. **1**: 1248. 1924) believed that the *F. varenga* in the East India Company collection at Kew was *F. bengalensis*. But King (1887) had examined no. 4560 in four collections of the plants represented by Wallich's list, had found that specimens in the Linnean Society, Kew, and De Candolle collections did not entirely agree, but was certain that specimens of *F. peguensis* and *F. varenga* which were labeled in Buchanan-Hamilton's handwriting were true *F. laccifera*. King referred especially to the Calcutta collection.

FICUS ALTISSIMA Blume var. FERGUSONII King, Ann. Bot. Gard. Calcutta **1**: 31. *pl. 31 C*. 1887.

Tree 24–30 m. high, air roots few, parts glabrous except for pubescent shoots; stipules lanceolate, coriaceous, 2.5–4.5 cm.; petioles 2–4 cm. long, stout; blades ovate, ovate-oblong, lanceolate or slightly obovate, 10–17.5 cm. long; base cuneate; apex cuspidate; no differentiated basal veins, 9–12 sets of secondary veins; figs axillary, sessile, subglobose, 1.3–2 cm. in diameter, orange-red, smooth; basal bracts 3, rounded, hoary, connate, at first enclosing the fig.

TYPE: *Thwaites*, Ceylon.

Distribution: Ceylon.

King's brief description and his plate have been amplified (as above) by Trimen (1898). Willis (Rev. Cat. Pl. Ceylon 83. 1911) also speaks of the variety as native to Ceylon. No specimens have been seen by the writer.

SUMMARY

The main differences between two tall "banyans" with somewhat similar leaves and figs are as follows. *F. bengalensis* L. has a much more widely spreading crown than has *F. altissima* Blume, and infinitely more secondary trunks. Its leaves usually are obtuse at the apex and velvety to the touch. They commonly have two sets of large basal veins. The ripe figs are globose, red, velvety, smaller than those of *F. altissima*, and have three separate leafy basal bracts. *F. altissima* has glossy leaves with a conspicuous light-colored V made by its single set of large basal veins, and a rounded apex bearing an abrupt acumen. The figs are ovoid, usually yellow and bare, and rest on a thick pad of united basal bracts. Both species now have a wide distribution; but *F. bengalensis* probably is native only to India and neighboring states, while *F. altissima* has been found wild from India to South China.

Varinga latifolia Rumph., *F. laccifera* Roxb., *F. peguensis* Buch.-Ham. ex Wall., and *F. varenga* Buch.-Ham. ex Wall. are among the synonyms.

F. altissima var. *fergusonii* King is native to Ceylon. It differs from the type principally in its narrower blades with more and always similar secondary veins, and in its subglobose figs.

The writer is grateful to those in charge of herbaria, libraries and botanical gardens who have made this study possible.

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THE FERNS OF KASHMIR

RALPH R. STEWART

The native state of Kashmir is the most northerly part of the British Indian Empire. It extends roughly from 32′ to 36′ north latitude and from 74′ to 78′ east longitude. It is bounded on the west by the Northwest Frontier Province, on the north by the U. R. S. S. and Sinkiang, on the northeast by Tibet, on the east by the Punjab Himalaya, and on the south by the Punjab. Except for the famous Vale of Kashmir the whole country is mountainous. The backbone of the Himalayas forms the watershed which separates the streams flowing toward the Punjab by the Jhelum and Chenab river systems from the streams which flow into the Indus. The Indus follows a remarkable course, flowing northwest from Tibet, curving around the Nanga Parbat range in the north of Kashmir, and then cutting across the whole of the Himalayan chain to enter the plains at Attock.

That part of Kashmir which is behind the main Himalayan range and is drained by the Indus is almost rainless in summer because the high mountains check the moisture-laden monsoon winds. However, there is a heavy snowfall in winter, which produces numerous glaciers and permanent snowfields. This part of Kashmir is Tibetan in character. It is treeless, except for willows, poplars, apricots, and a few other species which are cultivated by the villagers. Except for the alpine meadows near the snowfields and the irrigated land about the villages the whole country is desert. In this region the only common fern is *Cystopteris fragilis*.

South of the Himalayas conditions are very different. There is a semi-tropical foothill zone of low xerophytic shrubs, which gradually changes as one ascends into a scrub forest in which the chief trees are *Olea cuspidata* and *Acacia modesta*. At about 3000 feet *Pinus longifolia* comes in on the ridges and steep slopes. The temperate Himalayan zone begins between 5000 and 6000 feet, where *Pinus longifolia* is replaced by *P. excelsa* and temperate hardwoods of many familiar northern genera.

The Himalayan flora extends to the limit of tree growth at from 11,000 to 12,000 feet. The position of the tree line varies with local conditions and in some inner valleys the alpine zone descends to below 10,000 feet. Above the last trees, which are commonly birches (*Betula utilis*), one usually finds shrubby junipers, willows, and rhododendrons, which are gradually replaced by the herbs of meadows, moraines, and talus slopes. The permanent snow line is at about 14,000 feet on the south slope of the Himalayas and as high as 19,000 feet on the Tibetan side.

Ferns have been collected in this region for more than a hundred years, but I have not been able to find a list of Kashmir ferns; one could be compiled from the publications of Beddome (1), Clarke (6), and Hope (9), the three men who have done most work on the ferns of North India. This list is based on their work and on the rich collections at the Dehra Dun Herbarium of the Imperial Forestry Research Institute in the United Provinces, North India, on the collections at the Royal Botanic Gardens at Kew, on the Underwood Herbarium at the New York Botanical Garden, and on the collections at Gordon College, Rawalpindi, North Punjab.

Gordon College is fortunate in possessing the Trotter collection of ferns which lay for more than forty years in a private house in Murree. It consists of about 2000 sheets of Himalayan ferns accumulated by E. W. Trotter of the Punjab Post and Telegraph Department, chiefly between 1885 and 1892. He himself collected a great many, from the Indus on the west almost to the boundary of Nepal. He obtained a large number also by exchange, thus building up an excellent working collection which includes most of the ferns known to grow between the Indus and the Burma line. He had exchanged specimens with the numerous fern enthusiasts of that golden period of fern collecting in north India, so that his herbarium contains many specimens of Gustav Mann, C. W. Hope, the Mackinnon brothers, J. C. McDonell, H. F. Blanford, Col. R. W. MacLeod, J. S. Gamble, and other contemporaries. Trotter was the discoverer of *Dryopteris* (*Polypodium*) *laterepens*.

Besides the Trotter Collection the Gordon College Herbarium contains my own collections from 1912 to 1940, those made by Prof. Mohindar Nath, and a few hundred sheets which have come in by exchange.

I have not attempted to list all the synonyms which have been used for Kashmir ferns, but only to give the correct name according to the *International Rules of Botanical Nomenclature* (ed. 3. 1935), and enough synonymy to make it possible for one using the older works of Beddome or Clarke to locate the species. I have followed the *Index Filicum* of Carl Christensen for the generic and for most of the specific names. I have not attempted to list all the specimens seen, but to cite enough from the Gordon College collections and those of the New York Botanical Garden to indicate their distribution and abundance.

A new fern flora for British India is badly needed. Beddome's *Handbook* (1), though excellent in its day, is out of date. Since 1892 much collecting has been done, many additional species have been described, and generic concepts have changed. Beddome knew the ferns of South India much better than he did those of the north. C. B. Clarke and C. W. Hope have been the outstanding students of North Indian ferns, but their publications are not readily accessible, and need revision. No one should work on the ferns of North India without C. W. Hope's *Ferns of Northwestern India* (9). He

knew the ferns in the field and saw almost all the specimens which had been collected in the area before his time. It is unfortunate that his work was not published in book form instead of in parts in the *Journal of the Bombay Natural History Society*. He checked the determinations of all the Indian specimens in the Trotter collection and those at Dehra Dun and studied the Indian collections at Calcutta, Kew, and Dublin. Little work has been done on the ferns of North India since his time. He was able to build on the work of Clarke and he described 211 ferns growing to the west of Nepal, against 149 in Clarke's Review.

Although Kashmir is not so rich in ferns as the parts of the Himalaya farther east, it has more true ferns than are to be found in the northern part of the United States and Canada as treated by Britton and Brown in their *Illustrated Flora* (4). There are 106 species and varieties in the present list. C. B. Clarke admits 363 species for the whole of North India (omitting Lycopodiaceae and Equisetaceae), while Beddome treats 405 species and varieties. Although it is not likely that many Kashmir species have been overlooked entirely, there is still much work to be done. Many species are poorly represented in herbaria and ten per cent of the total have only been reported once. There are *Dryopteris hexagonoptera*, *D. hirtipes*, *D. marginata*, *D. macrocarpa* (*Schimperiana*), *D. repens*, *D. prolifera*, *Polystichum aristatum*, *Athyrium setiferum*, *Notholaena vellea*, *Polypodium Stracheyi*, and *Woodwardia radicans*. The first species was reported from Zanskar by Sir George Watt, and this is the only Indian record of it, but all the others grow east of Kashmir, where most of them are common. I suspect that some of them do not grow in Kashmir, but since they have been reported by Clarke or Beddome I have entered them in this list. Nine species are reported by Beddome or Clarke which neither Hope or I have been able to find in the field or in collections, and I do not know the basis of their inclusion as natives of the state. If they are really Kashmir plants I should expect to find them on the eastern border, for I have specimens of them all from farther east. They are *Dryopteris africana*, *D. repens*, *Leucostegia pulchra*, *Notholaena marantae*, *Polypodium microrhizoma*, *P. lachnopus*, *P. argutum*, *Cyclophorus porosus*, and *Diplazium maximum*. The parts of Kashmir most likely to yield new records are the southern slopes of the Pir Panjal Range from the Jhelum River to the Chamba line, especially the area nearest Chamba.

Although the fern flora of Kashmir cannot compare in richness with the area to the east where the ground ferns are supplemented by many epiphytes, yet it is quite rich in comparison with that of the British Isles, which have only 37 species, and has twice as many as are found in the Middle East. In the small area about Simla, in the Punjab Himalaya, there are 124 ferns; these were published in Collett's *Flora simlensis* (7) with identifications by Hope.

There seem to be no endemic species in the state.

A number of critical groups need further study. This is particularly true of the ferns formerly attached to *Dryopteris Filix-mas* as varieties but which are now recognized by C. Christensen and others as species, and the ferns called *Dryopteris Linnaeana* or *D. Robertiana*. More work needs to be done on the linear-leaved species commonly referred to as *Polypodium lineare* or *P. loriforme*. The ferns related to *Athyrium Filix-femina* are also difficult.

From the standpoint of distribution the most interesting fern is *Microlepia Wilfordii*, which has not been found anywhere else in India but which grows in Japan, Korea, and China. It was discovered in 1897 by McDonell in the Buniar Nullah near Rampur in the Jhelum Valley at about 4000 feet, and I found it in 1927, possibly in the same spot.

There are enough widespread northern ferns growing in Kashmir to make an American or European botanist feel at home while collecting there, especially in the temperate and alpine zone. The following, listed in Britton and Brown's *Illustrated Flora*, are also Kashmir plants, and most of them are common there.

Osmunda Claytoniana
Woodsia alpina
Cystopteris fragilis
C. montana
Dryopteris thelypteris
D. phegopteris
D. Linnaeana
D. Filix-mas
Asplenium trichomanes
A. viride
A. Ruta-muraria
A. fontanum
Athyrium Filix-femina
A. acrostichoides
Adiantum Capillus-veneris
A. pedatum
Pteridium aquilinum
Cryptogramma Stelleri

A number of others, not found in America, are North European ferns, while others belong to the Mediterranean flora. Four of the five ferns listed by Pampanini in his *Flora of Tripolitania* (10) are Kashmir plants. They are *Adiantum Capillus-veneris, Ceterach officinarum, Cheilanthes pteridioides,* and *Notholaena vellea,* while the fifth, *Anogramma* (*Gymnogramma*) *leptophylla,* grows to the east of Kashmir and may have been overlooked.

Of the 24 ferns in Post's *Flora of Syria, Palestine and Sinai* (11) all but five are found in Kashmir or to the east of Kashmir. Those in common are

Osmunda regalis
Anogramma leptophylla
Ceterach officinarum
Notholaena marantae
Cheilanthes pteridioides
Pteris cretica
P. vittata ("*P. longifolia*" Auct.)
Pteridium aquilinum
Adiantum Capillus-veneris
Asplenium fontanum
A. trichomanes
A. Ruta-muraria
A. Adiantum-nigrum
A. septentrionale
Athyrium Filix-femina
Polystichum aculeatum
Dryopteris thelypteris
Dryopteris Filix-mas vel. aff.
Cystopteris fragilis

Boissier (3) describes 54 ferns found in Persia and adjacent countries, all but 18 of which grow in Kashmir.

Kashmir is just west of the area which has enough moisture during the monsoon to permit an epiphytic flora. Only a few miles to the east the zone of epiphytes begins, and the nearer one gets to the Bay of Bengal the richer the forests are in epiphytic ferns, orchids, aroids, mosses, liverworts, and lichens. From the region extending two hundred miles to the west of Kashmir only a few ferns are known which do not grow in the state, while more than a hundred others appear within two hundred miles eastward. *Adiantum aethiopicum* is the only fern I know from the Afghan frontier which does not grow in Kashmir or to the east of Kashmir. General Gatacre found 27 ferns in the Chitral region (8), of which all are Indian and 19 are European. The two most remarkable finds are *Dryopteris ludens* and *Lygodium microphyllum*, which do not grow in Kashmir but are known from farther east.

There are a number of tropical or subtropical ferns in the Kashmir foothills, but this element is not very large because of the long dry season and the small number of perennial waterfalls or streams. The Mediterranean ferns find themselves more at home here. Examples of the tropical element are *Dryopteris rampans*, *Dryopteris dentata* (*parasitica*), *D. prolifera*, *Pteris vittata*, *Cyrtomium caryotideum*, *Polypodium membranaceum*, and *Adiantum caudatum*.

A note is perhaps necessary in explanation of the varied spelling of Indian place names. There has been an evolution in the spelling of many names. Kashmir was formerly Cashmere. Rawalpindi was Rawul Pindee. The Punjab was the Punjaub and should probably be written Panjab. The province with headquarters at Karachi has been spelled Scinde, Scind, or Sind. Even good maps differ in the spelling of names. One reason is that the natives themselves differ and another is that scientific visitors are dependent on their pony men or coolies for names and with no better guide it is not strange that variations crept in. The sound is the important thing and small differences in spelling should be overlooked.

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POLYPODIACEAE

WOODSIA ALPINA (Bolton) Gray, Nat. Arr. Brit. Pl. **2**: 17. 1821. *Acrostichum alpinum* Bolton, Fil. Brit. 76. 1790. *Woodsia hyperborea* R. Br. Prodr. Fl. Nov. Holl. **1**: 158. 1810.

Sonamarg, *6829*[1]; Mt. Kolahoi, *9446;* Masjid Valley, *Duthie 13,226;* Thajwas Nullah, *Duthie 13,644;* Sonsal Nullah, 13,000–14,000 feet, *Duthie.*

An alpine plant of rock clefts. Not common.
Distribution: Boreal North America, central Europe, Himalaya, Altai.

CYSTOPTERIS FRAGILIS (L.) Bernh. Schrad. Jour. Bot. **1**[2]: 27. 1806. *Polypodium fragile* L. Sp. Pl. 1091. 1753.

The commonest fern at high altitudes and almost the only fern in the Tibetan zone behind the Himalayas. It is usually found from 10,000 to 15,000 feet but I found it as low as 5500 feet under a rock in the Keran Nullah, Kishenganga Valley. It varies greatly in size.
Distribution: The Arctic and Antarctic zones and the mountains of the world.

CYSTOPTERIS MONTANA (Lam.) Bernh.; Desv. Mém. Soc. Linn. Paris **6**: 264. 1827. *Polypodium montanum* Lam. Fl. Fr. **1**: 23. 1778. *Filix montana* Underw. Nat. Ferns ed. 6, 119. 1900.

Bungas, Muzaffarabad, *Inayat 20,786;* Gulmarg, in woods, 9000 feet, *Aitchison;* Sonamarg, 10,500 feet, rock crevices in birch forest, *6868;* 3–9–1884, *Duthie 3647.*

A rare fern at high levels.
Distribution: Boreal North America, Europe, Asia.

DRYOPTERIS ROSTHORNII (Diels) C. Chr. Ind. Fil. 289. 1905; Suppl. 3: 96. 1934. *Nephrodium Rosthornii* Diels, Engl. Jahrb. **29**: 190. 1900. *Nephrodium Filix-mas* var. *fibrillosa Clarke,* Trans. Linn. Soc. II. **1**: 520, *pl. 70.* 1880. *Lastrea Filix-mas* var. *parallellogramma* Bedd. Handb. 249, in part. 1883.

Sonamarg, *6340; 13,451;* Khillanmarg, above Gulmarg, *10,412;* Pahlgam, *8141; 8242;* Keran, *17,264;* Below Kel, Kishenganga Valley. Alt. 6000–11,000 feet.

This is a beautiful, shuttlecock-like form with shiny black scales. It is only once pinnate, the pinnules are very regular and only slightly denticu-

[1] Specimens listed without collector's name are those of the author.

late. It replaces the more eastern *D. paleacea* in Kashmir. It is very close to *D. Blanfordii* but is usually smaller, with darker ramentae and pinnules less denticulate.
Distribution: Himalaya, China.

DRYOPTERIS FILIX-MAS (L.) Schott. Gen. Fil. ad *pl. 9.* 1834. *Polypodium Filix-mas* L. Sp. Pl. 1090. 1753. *Nephrodium Filix-mas* Rich.; Marthe, Cat. Jard. Méd. Paris 129. 1801. *Aspidium Filix-mas* Sw. Schrad. Jour. Bot. **1800**[2]: 38. 1801.

Hirpour, *Jacquemont 586;* Rembiara Valley, 6500–7000 feet, *Trotter 191;* Liddarwat, 9000 feet, *Trotter 404;* also specimens of MacLeod, Duthie, and McDonell. Cited by Hope, Jour. Bomb. Nat. Hist. Soc. **14**: 727. 1903.

Distribution: Temperate parts of the world except Australia and southern South America.

DRYOPTERIS BLANFORDII (Hope) C. Chr. Ind. Fil. 254. 1905. *Nephrodium Blanfordii* Hope, Jour. Bomb. Nat. Hist. Soc. **12**: 624. *pl. 11.* 1899. *Nephrodium remotum* of Blanford, Jour. As. Soc. Beng. **57**[2]: 4. 1888; non Hook. 1861.

Pahlgam, *5324a; 8128;* Sonamarg, *9744; 9767; 13,452;* Nagmarg and Sonamarg in 1888, *Trotter,* cited by Hope. Alt. usually 6000–9000 feet.

Close to *D. Rosthornii* when the specimens are small and the pinnules are more nearly entire than usual. The pinnae are not so regularly cut or so close together and the basal ramentae are shorter and broader and not so numerous upward on the rachis. The scales are dark, black or brownish-black. The short stipe is a good character in distinguishing this species from *D. odontoloma.*
Distribution: North India.

DRYOPTERIS ODONTOLOMA (Moore) C. Chr. Acta Hort. Goth. **1**: 59. 1924; Suppl. **3**: 93. 1934. *Dryopteris Filix-mas* var. *odontoloma* (Moore) C. Chr. Index 265. 1905. *Lastrea odontoloma* Moore, Ind. Fil. 90. 1858. *Nephrodium Filix-mas* var. *normalis* Clarke, Tr. Linn. Soc. II. **1**: 521. *pl. 71.* 1880. ? *Nephrodium rigidum* Clarke, l.c. 523. *Nephrodium odontoloma* Hope, Jour. Bomb. Nat. Hist. Soc. **14**: 736. *pl. 31.* 1903.

Batot, Jumu Road, *12,483;* Between Uri and Aliabad, *13,982c;* Titwal to Surkhala, Kishenganga Valley, *71,445;*? Burzil Chowki, *19,782;* Sonamarg, *6334;* Mitsahoi, Ladak Road, *9920a;* Gilgit, 10,000 feet, in 1847, *Winterbottom,* cited by Hope. Alt. 3000–10,000 feet.

This is another variable fern belonging to the *D. Filix-mas* complex which is sometimes difficult to tell from *D. Blanfordii* on the one hand and *D. marginata* and *D. ramosa* on the other. It is usually twice pinnate and the stipe is long, not short as in *D. Blanfordii.* The sori are small and the pinnae are distant, increasingly so downwards. The three to five lowest pinnae are barren. The stipes are paler and more straw-colored than in *D. Blanfordii* and the fronds dry a pale color. The general outline of the frond is oblong lanceolate to ovate or deltoid lanceolate. *D. marginata* and *D. ramosa* are usually larger, tripinnate instead of bipinnate, and the general outline of the frond is more triangular.
Distribution: Afghanistan to Assam, Mts. of South India. China.

DRYOPTERIS MARGINATA (Wall.) Christ, Phil. Jour. Sci. **2**: 212. 1907. *Aspidium marginatum* Wall. List 391, nomen, in part. 1829. *Nephrodium Filix-mas* var. *marginata* Clarke, Trans. Linn. Soc. II. **1**: 521. *pl. 71.* 1880. *Nephrodium Filix-mas* var. *elongatum* auct. *Nephrodium marginatum* Hope, Jour. Bomb. Nat. Hist. Soc. **14**: 740. *pl. 33.* 1903.

Hope cites Col. MacLeod as authority for treating *D. marginata* as a Kashmir plant. MacLeod states that it is common from 6000 to 11,000 feet between the Jhelum and Kishenganga Valleys. I am not sure whether authentic *D. marginata* grows in Kashmir or not; it becomes common east of Kashmir. It is a large fern, often tripinnate, with long stipes; the outline of the frond is triangular.
Distribution: North India, South China.

DRYOPTERIS RAMOSA (Hope) C. Chr. Ind. Fil. 287. 1905. *Nephrodium ramosum* Hope, Jour. Bot. **34**: 126. 1896; Jour. Bomb. Nat. Hist. Soc. **14**: 739. *pl. 32.* 1903.

Dras Valley, *Duthie 11,667;* Pahlgam, *5725;* near Gulmarg, *10,401a; 10,447;* Banihal Pass, *14,089b;* Sharda, Kishenganga Valley, *17,776;* above Chorwan, *18,602;* Badwan, *19,562; 19,602;* etc.

This is the largest of the species related to *D. Filix-mas* which is common in Kashmir and largely if not completely replaces *D. marginata* in the state. Hope well states the characteristic features of the species "frond broad, hardly ever reduced at the base, pinnae, very long, broad and distant; pinnules, very long and narrow; frond pale green in color and scales almost invariably pale." It is perhaps nearest to *D. Blanfordii*, which may be distinguished by the dark ramentae, short stipe, and less compound cutting.
Distribution: Afghanistan to Tehri Garhwal.

Dryopteris macrocarpa R. R. Stewart, nom. nov. *Lastrea Filix-mas* var. *elongata* Bedd. Handb. 250. 1883. *Lastrea Filix-mas* var. *Schimperiana* Bedd. Handb. Suppl. 58. 1892. *Dryopteris cochleata* var. *Schimperiana* C. Chr. Ind. Fil. Suppl. **3**: 86. 1934. *Nephrodium Schimperianum* Hope, Jour. Bomb. Nat. Hist. Soc. **14**: 733. 1903. *Nephrodium Filix-mas* var. *Schimperiana* Clarke, Trans. Linn. Soc. II. **1**: 520. *pl. 69, f. 2.* 1880.

Only reported by Trotter from Rattanpir at 8000 feet. Becomes very common farther east and is one of the commonest ferns in the *Quercus incana* zone at Mussoorie. I consider it to be distinct and cannot understand why C. Christensen united it with *D. cochleata*. *D. cochleata* is dimorphic with many sterile fronds and the lower surfaces of the fertile fronds are completely hidden by the sori. This is not the case in *D. macrocarpa*. According to Christ the Ethiopian material is different from Indian "*D. Schimperiana.*" See Hope, Jour. Bombay Nat. Hist. Soc. **14**: 734. 1903.
Distribution: Kashmir to Assam.

DRYOPTERIS SERRATO-DENTATA (Bedd.) Hayata, Ic. Pl. Formosa **4**: 179. *pl. 116.* 1914. *Lastrea Filix-mas* var. *odontoloma* of Bedd. Ferns Brit. Ind. 248. *pl. 373.* 1863–5. *Lastrea Filix-mas* var. *serrato-dentata* Bedd. Handb. Suppl. 55. 1892. *Nephrodium serrato-dentatum* Hope, Jour. Bomb. Nat. Hist. Soc. **12**: 622. *pl. 10.* 1899. ? *Nephrodium Kingii* Hope, Jour. Bomb. Nat. Hist. Soc. **12**: 621. *pl. 9.* 1899.

Chatponsal Nullah, *Duthie 13,221;* Sind Valley near Baltal, *Duthie 11,613.* Both cited by Hope.

A very rare high level fern, closely related to *D. barbigera* and *D. Brunoniana,* but more delicate. The stipes are very long for the size of the plant, being as long as or longer than the frond. The basal scales wear off more easily than they do in *D. barbigera.*
Distribution: Hazara to Bhotan, China.

DRYOPTERIS BARBIGERA (Moore) Kuntze, Rev. Gen. **2**: 812. 1891. *Nephrodium barbigerum* Moore ex. Hook. Sp. Fil. **4**: 113. 1862. *Lastrea barbigera* Bedd. Ferns Brit. Ind. *pl. 227.* 1867.

This is a very common and handsome alpine fern growing gregariously on alpine meadows. The fronds are broad for their length while in *D. Brunoniana* they are comparatively narrow. The stipe and rachis of *D. Brunoniana* are black or reddish-black, blacker than the scales, while those of *D. barbigera* are pale brown, paler than the scales (Hope). Alt. 9000–13,000 feet.
Distribution: Afghanistan to Sikkim, China.

DRYOPTERIS BARBIGERA var. **Falconeri** (Hook.) R. R. Stewart, comb. nov. *Nephrodium Falconeri* Hook. Sp. Fil. **4**: 123. 1862. *Lastrea Falconeri* Bedd. Ferns Brit. Ind. *pl. 41.* 1865.

Hooker's species was based on a single frond of Falconer's from Kashmir. Clarke considered *D. Falconeri* to be the same as *D. barbigera,* as did Beddome in his Handbook (p. 248. 1892). There are specimens like my *8642* and *10,645* from Khillanmarg, above Gulmarg with larger fronds, the pinnules longer and narrower, and the rachises more glandular-resinous. Perhaps they are no more than a vigorous form of *D. barbigera* and not worth a separate name.

DRYOPTERIS BRUNONIANA (Wall.) Kuntze, Rev. Gen. **2**: 812. 1891. *Aspidium Brunonianum* Wall. List 344, nomen. 1829. *Lastrea Brunoniana* Pr. Tent. 76. 1836. *Nephrodium Brunonianum* Hook. Sp. Fil. **4**: 113. *pl. 251.* 1862.

Trunkal, Gangabal Lakes, *4551;* Sonamarg, *3542; 6664;* Pahlgam, *5901;* Mt. Kolahoi, *8275a;* Khillanmarg, *8658a; 10,415; 10,422;* Kamri Pass, *18,715;* Zojibal to Mengandob, *18,253;* Burzil to Deosai, *19,994;* etc. Alt. 10,000–16,000 feet.

A common high level fern.
Distribution: Hazara to Bhotan.

DRYOPTERIS CRENATA (Forsk.) Kuntze, Rev. Gen. **2**: 811. 1891. *Polypodium crenatum* Forsk. Fl. Aegypt.-Arab. 185. 1775. *Lastrea crenata* Bedd. Ferns Brit. Ind. 18. 1876.

Not listed from Kashmir by either Beddome or Hope, but I found it between Muzaffarabad and Dhanni in the Kishenganga Valley and at Ramban, Jumu Road, 3000 feet, *10,732.* There is also a specimen from the Tawi Valley, 5000 feet, by Trotter.

This is one of the finest ferns in the Himalayas and very easily recognized. It likes the sun and grows on cliffs in the outer hills, usually from 2000 to 6000 feet. The rhizome is usually wedged firmly in the rocks and the

base of the stipe is covered by long, chestnut-colored scales unlike those of any other fern in North India. Common on limestone.
Distribution: Cape Verde Islands to North India, Malacca, South China.

DRYOPTERIS THELYPTERIS (L.) A. Gray, Man. 630. 1848. *Acrostichum thelypteris* L. Sp. Pl. 1071. 1753. *Lastrea thelypteris* Bory, Dict. Class. **9**: 233. 1826.

Kangan, Sind Valley, 6000 feet, *6925; 13,450.* Near Dal Lake, Srinagar, 5200 feet, *Thomson, Gammie, Levinge,* etc.

This is a plant of springs and shallow water.
Distribution: Most parts of the northern hemisphere, New Zealand.

DRYOPTERIS REPENS (Hope) C. Chr. Ind. 288. 1905. *Nephrodium repens* Hope, Jour. Bomb. Nat. Hist. Soc. **12**: 535. 1899. ? *Nephrodium prolixum* Baker, Syn. Fil. 268. 1867.

I include this in the list of Kashmir ferns on the authority of Clarke. Hope found no Kashmir specimens, nor have I. It is common from Chamba eastward.
Distribution: North India, Sierra Leone.

DRYOPTERIS RAMPANS (Bak.) C. Chr. Ind. Fil. 287. 1905. *Nephrodium rampans* Bak. Jour. Bot. **27**: 177. 1889. *Polypodium lineatum* Colebr. Wall. List 300, nomen. 1829. *Goniopteris lineata* Bedd. Pr. Tent. 183. 1836. *Nephrodium costatum* of Bedd. Handb. 275. 1883.

Jhelum Valley Road, 35th mile, *MacLeod;* Tawi Valley, 4000 feet, *Levinge;* Pooneh, 3000 feet, *Sage,* as *D. multilineatum.* Alt. 3000–7000 feet.

This plant has often been called *D. penangiana,* a plant of Malacca and Borneo (see. C. Chr. Index. Fil. Suppl. **3**: 94. 1934). It is a large fern growing at low altitudes in the outer ranges on damp shady banks. The leaflets are narrower and smaller than in *D. moulmeinensis* with which it has been confused. At Mussoorie the fertile fronds come up in August.
Distribution: North India and China.

DRYOPTERIS ERUBESCENS (Wall.) C. Chr. Ind. Fil. 263. 1905. *Polypodium erubescens* Wall. List 330, nomen. 1829. *Phegopteris erubescens* J. Sm. Hist. Fil. 233. 1875.

Jhelum Valley Road, 3000 feet, *Trotter;* Jumu Road near Banihal Village, Kishenganga Valley, 3000 feet (Herb. Gordon); Basaoli, 5500 feet, *Clarke.* Alt. 3000–7000 feet.

A large fern growing in the wet ground below springs or by the side of streams, suggesting a *Pteris.* Grows in the same sort of places as *Woodwardia radicans.* Not common in Kashmir but becomes abundant farther east.
Distribution: North India, Malaya, South China.

DRYOPTERIS HIRTIPES var. ATRATA (Wall.) C. Chr. Contr. U. S. Nat. Herb. **26**: 278. 1931. *Aspidium atratum* Wall. List 380, nomen. 1829. *Lastrea atrata* Pr. Tent. 77. 1836. *Nephrodium hirtipes* Hook. Sp. Fil. **4**: 115. 1862. *Lastrea hirtipes* Moore, Ind. Fil. 85. 1858.

McDonell found this at Ghantamula in 1891 at 5300 feet and his are the only Kashmir specimens I have seen. Very rare.
Distribution: Himalaya, South China.

DRYOPTERIS LATEREPENS (Trotter) C. Chr. Ind. Fil. 274. 1905. *Polypodium repens* Trotter; Hope, Jour. Bomb. Nat. Hist. Soc. **12**: 628. *pl. 14.* 1899.

Chittapani Valley and Rattanpir, 7500–8500 feet, *Trotter;* Dardpura, 4000–6000 feet, *MacLeod.*

This is a plant of swampy or wet ground and the type collections are in the Trotter Herbarium at Gordon College. The rhizome is necessary to distinguish it from *D. brunnea,* with which it has often been confused. All the specimens labelled *D. brunnea* in the Dehra Dun Herbarium are without rhizomes and cannot be identified with certainty; I suspect that they are really *D. laterepens.*
Distribution: North India.

DRYOPTERIS LEVINGEI (Clarke) C. Chr. Ind. Fil. 275. 1905. *Gymnogramme aurita* var. *Levingei* Clarke, Trans. Linn. Soc. II. **1**: 568. 1880. *Gymnogramme Levingei* Baker, Ann. Bot. **5**: 483. 1891.

Pahlgam, 7500 feet, *5334;* 5489; Gulmarg, *10,206a;* Surkhala to Keran, 5000–6000 feet, *17,554.* Alt. 4500–9500 feet.

Like *D. laterepens,* this has a creeping rootstock and grows in damp soil.
Distribution: Himalaya.

DRYOPTERIS DENTATA (Forsk.) C. Chr. Vid. Selsk. Skr. VIII. **6**: 24. 1920. *Polypodium dentatum* Forsk. Fl. Aegypt.-Arab. 185. 1775. *Dryopteris parasitica* auct. non L.

Domel, 2000 feet, *5150;* Garhi, 3000 feet, *5145;* Chenari, 3500 feet, *12,170.* All Jhelum Valley Road.

This is a common fern in the foothills up to about 3000 feet and is often called *Nephrodium molle, Dryopteris parasitica,* or *D. subpubescens.* The lower pinnae of *D. dentata* are gradually reduced to mere auricles, while in *D. parasitica* (L.) Kuntze the basal pinnae are unreduced. Is *D. subpubescens* a synonym?
Distribution: Tropical America, Atlantic Islands, Africa, Arabia, India, Tropical Asia?

DRYOPTERIS AFRICANA (Desv. C. Chr. Ind. Fil. 251. 1905. *Polypodium africana* Desv. Prod. 239. 1827. *Gymnogramma totta* Schlecht. Adumbr. 15. *pl. 6.* 1825. *Leptogramma totta* J. Sm. Jour. Bot. **4**: 52. 1841.

Reported from Kashmir by Beddome without data. I have seen no specimens. It grows from Chamba eastward.
Distribution: Azores, North Africa, India, Malaya, China, Japan.

DRYOPTERIS PROLIFERA (Retz.) C. Chr. Ind. Fil. 286. 1905. *Hemionitis prolifera* Retz. Obs. **6**: 38. 1791. *Polypodium prolifera* Roxb. Wall. List 312, nomen. 1829. *Goniopteris prolifera* Pr. Tent. 183. 1836.

The only Kashmir record seems to be *Jacquemont 1419* from Rajaori in Poonch. It is a vigorous plant of the plains or low foothills, commonly growing in ditches. In 1928 I collected it at Maksud in Hazara (*9653*) and it probably grows in the foothills of Poonch and Jumu. It becomes common toward the east, like many other ferns which are not common in Kashmir.
Distribution: Tropical Africa, India, Malaya, China, Polynesia, Australia.

DRYOPTERIS PHEGOPTERIS (L.) C. Chr. Ind. Fil. 284. 1905. *Polypodium phegopteris* L. Sp. Pl. 1083. 1753. *Phegopteris vulgaris* Mett. Fil. Lips. 83. 1856.

Khillanmarg, above Gulmarg, 10,000 feet, *8698;* Gulmarg, 8000 feet, *10,480;* Sonamarg, 9000 feet, *9702;* Rajdhiangan Pass, 9000–10,000 feet, *18,003; 19,478.* Alt. 9000–12,000 feet.

Grows in forest humus. Easily recognized by the deflexed basal pinnae and the pubescence.
Distribution: Temperate and arctic America, Europe, North Asia, Himalaya, Japan, etc.

DRYOPTERIS LINNAEANA, C. Chr. Ind. Fil. 275. 1905. *Polypodium dryopteris* L. Sp. Pl. 1093. 1753. *Phegopteris dryopteris* Fée, Gen. 243. 1850–52. ? *Gymnocarpium dryopteris* var. *disjunctum* (Rupr.) Ching, Contr. Biol. Lab. Sci. Soc. China Bot. **9**: 41. 1933.

A number of specimens from Kashmir and the adjacent mountains have been referred to *D. Linnaeana.* Ching cites two Indian specimens as being his var. *disjunctum,* a Hooker and Thomson specimen from Kishtwar and *Aitchison 382* from the Afghan frontier. Not having seen them, I cannot say whether they are the same as specimens hitherto referred to *D. Linnaeana* or to *D. Robertiana* in India.
Distribution: Temperate and arctic America; North Europe and Asia, Western Himalaya, China, Japan.

DRYOPTERIS ROBERTIANA (Hoffm.) C. Chr. Ind. Fil. 289. 1905. *Polypodium Robertianum* Hoffm. Deuts. Fl. **2**: 20. 1795. *Polypodium calcareum* Sm. Fl. Brit. 1117. 1804. *Phegopteris Robertiana* A. Br.; Aschers. Fl. Brand. **2**: 198. 1859. ? *Gymnocarpium remotum* Ching, Contr. Biol. Lab. Sci. Soc. China **9**: 41. 1933.

Tragbal, *4562;* Sonamarg, *7188;* Aliabad Pass, *13,690;* Ferozepur Nullah, *14,753;* Keran to Reshna, Kishenganga Valley, *17,681;* Sharda, *17,775;* Chorwan to Kamri, *18,625;* Rajdhiangan Pass, *19,479;* Chorwan to Minimarg, *19,709.* Alt. 5000–11,000 feet.

There has been much difference of opinion about the two Indian oak ferns. Hope did not think it worth while to keep them distinct in India, although there are specimens which might be sorted out as one or other of the two species which are recognized in Europe. Clarke only reported one species for India but he was inclined to unite the two European forms as well. He concludes by saying: "If *P. Robertianum* be distinct it grows in the West Himalaya." Christensen recognizes both as Asiatic plants. Ching revives the generic name *Gymnocarpium* for the oak ferns and recognizes three species which he keys out as follows:

Frond tripartito-bipinnatifid. *Eugymnocarpium.*

Habit "gracile," the two lateral divisions almost as large as the terminal; lamina perfectly naked and glabrous. *G. dryopteris.*
Habit much stouter, the two lateral divisions much smaller than the terminal.
Lamina eglandular or sometimes only rachis, at the insertion, sparsely and shortly glandular. *G. remotum.*
Rachis and underside of lamina always densely glandular. *G. Robertianum.*

The Indian material does not seem to sort out satisfactorily into Ching's units, but is mostly intermediate between his *G. dryopteris* and *G. Roberti-*

anum. It is more glandular than his first two species and usually less glandular than his third. He states that his *G. Robertianum* is always on limestone debris but my recollection is that in India it grows usually in forest humus. It seems to me that what we have in India is a variable group of plants with some specimens almost glabrous and with the two lower pinnae almost as large as the rest of the frond, thus approaching *D. Linnaeana*, while the bulk of the material is nearer *D. Robertiana*, being more or less glandular and with the basal pinnae relatively smaller.
Distribution: North America, Europe, Afghanistan, North India, China.

DRYOPTERIS HEXAGONOPTERA (Michx.) C. Chr. Ind. Fil. 270. 1905. *Polypodium hexagonopterum* Michx. Fl. Bor. Am. **2**: 271. 1803. *Phegopteris hexagonoptera* Fée, Gen. Fil. 243. 1850–52.

Only reported by Watt from Zanscar (Zanskar) a province of Ladak, behind the main Himalayan range and north of Simla. Not seen.
Distribution: North America.

HYPOLEPIS PUNCTATA (Thunb.) Mett. Kuhn. Fil. Afr. 120. 1868. *Polypodium punctatum* Thunb. Fl. Jap. 337, 1784. *Dryopteris punctata* C. Chr. Ind. 287. 1905. *Phegopteris punctata* Mett. Ann. Lugd. Bat. **1**: 222. 1864.

Ramsu, Jumu-Kashmir Road, on steep bank, 4000 feet, Aug. 1931, *12,465*. New to Kashmir.

Distribution: Widespread in the tropics of both hemispheres.

POLYSTICHUM LONCHITIS (L.) Roth, Röm. Mag. **2**[1]: 106. 1799. *Polypodium Lonchitis* L. Sp. Pl. 1088. 1753.

Sonamarg, fir woods, 9000 feet, *3507; 6311;* Apharwat, 11,000 feet, *8638;* Rajdhiangan Pass, 11,000–12,000 feet, *18,027;* Kamri Pass, 11,000–12,000 feet, *18,692;* Minimarg, Kishenganga Valley, 9000–10,000 feet, *19,159*.

This has been considered to be rare in Kashmir but I find it fairly common from 9000 to 12,000 feet.
Distribution: Europe, colder parts of Asia and America. Northwest Frontier Province and Kashmir.

POLYSTICHUM LACHENENSE (Hook.) Bedd. Ferns Brit. Ind. *pl. 32*. 1865.

Sonamarg, *7270; 9843;* Nafran near Har Nag, Upper Lidder Valley, *12,468;* Zojibal Pass, *18,202;* Kamri Pass, *18,727*. Alt. 12,000–14,000 feet.

A plant of crevices at high altitudes. Like those of *P. Lonchitis* the old petioles of former years last over. Some smaller and more delicately cut specimens suggest *P. Thomsoni*. The species is smaller and less scaly than *P. Prescottianum*, which is a plant of open hillsides rather than rock crevices.
Distribution: Alpine Himalaya, China.

POLYSTICHUM PRESCOTTIANUM (Wall.) Moore Ind. Fil. 101. 1858. *Aspidium Prescottianum* Wall. List 363, nomen. 1829.

One of the commonest ferns in the cold temperate and alpine zone. It grows in the open and is gregarious so that there are usually dense masses on the hillside. *Dryopteris barbigera* and *D. Brunoniana*, *Athyrium Filix-foemina* var. *dentigera*, and *Osmunda Claytoniana* grow in similar places.

The fronds are narrow for their length and there are usually from 35 to 40 pairs of pinnae. Alt. 8000–13,000 feet.
Distribution: Abundant in the Himalaya from the Kurram Valley to Sikkim.

POLYSTICHUM PRESCOTTIANUM Moore var. BAKERIANUM W. S. Atkinson ex Clarke, Trans. Linn. Soc. II. **1**: 510. *pl. 66*. 1880. *Aspidium Bakeriana* Atkinson ex Hook. Ic. *pl. 17*. 1886. *Polystichum Bakerianum* Diels in E. & P. Nat. Pfl. **1**[4]: 191. 1899.

Sind Valley, 12,000 feet, *Clarke;* Sarpat, *McDonell;* Trunkal, Gangabal Lakes, 11,000 feet, *18,144*. Alt. 10,000–13,000 feet.

The fronds are larger and broader and the upper surface of the leaves is practically glabrous but, as Clarke felt, there is no good break between this and the typical *P. Prescottianum*.
Distribution: Alpine Himalaya.

POLYSTICHUM THOMSONI (Hook.) Bedd. Ferns Brit. Ind. *pl. 126*. 1866. *Aspidium Thomsoni* Hook. 2 Cent. *pl. 25*, in part. 1860; Sp. Fil. **4**: 7. 1862.

Pushana, Winterbottom, 6500 feet; Chittapani Vy., 7500–8000 feet, *Trotter 221;* Kishtwar, *Atkinson;* Tarkiti, Indus Vy., Baltistan, 7000–8000 feet and Shyok Vy., *T. Thomson;* Har Nag, Upper Lidder Vy., rock crevices, 12,500 feet, *9342;* Ascent Mir Panzil Pass to the Deosai, 12,000 feet, *20,005*. Alt. 7000–13,000 feet.

This is a rather rare fern resembling a small and delicate *P. Prescottianum*. Clarke points out that the type sheet is in part *P. Prescottianum*.
Distribution: Baltistan to Sikkim.

POLYSTICHUM TSUS-SIMENSE (Hook.) J. Sm. Hist. Fil. 219. 1875. *Aspidium tsus-simense* Hook. Sp. Fil. **4**: 16, *pl. 220*. 1862. *Aspidium luctuosum* Hope, Jour. Bombay Nat. Hist. Soc. **14**: 474. 1902. ? *Aspidium luctuosum* G. Kunze, Linnaea **10**: 548. 1835–6.

Jhelum Vy., 3500 feet; Chittapani Vy., 7500–8000 feet, *Trotter;* Jhelum Vy. near Rampur, 4500 feet, *MacLeod;* Upper Chenab Vy., 6500 feet, *McDonell;* Rampur, Jhelum Vy., *12,148;* Below Titwal, Kishenganga Vy., 3000 feet, *17,387*. Alt. 3000–8000 feet.

Distribution: Temperate Himalaya, China, Japan.

POLYSTICHUM SQUARROSUM (Don) Fée, Gen. Fil. 278. 1850–52. *Aspidium squarrosum* Don, Prodr. Fl. Nepal 4. 1825. *Polystichum aculeatum* var. *rufobarbatum* (Wall.) Bedd. Handb. 207. 1883. *Aspidium rufobarbatum* Wall. List 369, nomen. 1828.

According to Clarke, p. 509, this fern is found from Kashmir to Bhotan and in the Nilghiri Hills. I have not found what I would call typical *squarrosum* in Kashmir, and Hope gives its distribution from Chamba eastward.
Distribution: Himalaya, Chamba to Assam, 5000–8000 feet. Kashmir?

POLYSTICHUM ACULEATUM (L.) Schott, Gen. Fil. ad *pl. 9*, sensu lat. 1834. *Polypodium aculeatum* L. Sp. Pl. 1090, in part. 1753. *Aspidium angulare* Willd. Sp. Pl. **5**: 257. 1810. *Polystichum angulare* Pr. Tent. 83. 1836.

Chittapani Vy., 8000 feet, *Trotter;* Dardpura, 5000–7000 feet and Aud'rbug, 7000 feet, *MacLeod;* Pir Punjal and Gulmarg, 7000 feet, *Gammie;* Rampur, *12,259a;* Surkhala to Keran, Kishenganga Vy., 4500 feet, *17,493;* Keran, 5000–6000 feet, *17,637*. Alt. 4500–8000 feet.

This species is not as common in Kashmir as farther east. *P. aculeatum* is a "catch-all"; Hope used the name *P. angulare* for the Indian plants. Christensen says that this is a composite species which needs division but that the synonymy is very complicated.
Distribution: The composite species is found throughout the world in the temperate and tropical zones.

POLYSTICHUM ARISTATUM (Forst.) Pr. Tent. 83. 1836. *Polypodium aristatum* Forst. Prodr. 82. 1786. *Aspidium aristatum* Sw. Schrad. Jour. **1800**[2]: 37. 1801. *Nephrodium aristatum* Pr. Rel. Haenk. **1**: 37. 1825.

Trotter published a private list in which he stated that *Nephrodium aristatum* var. *affinis* Wall. List 370 had been collected in two places in Kashmir. No other Kashmir record but it is found from Chamba to Nepal.

CYRTOMIUM CARYOTIDEUM (Wall.) Pr. Tent. 86. *pl. 2, f. 26.* 1836. *Aspidium caryotideum* Wall. List 376, nomen. 1829. *Polystichum falcatum* Diels in E. & P. Nat. Pfl. **1**[4]: 194. 1899. *Polystichum falcatum* ssp. *caryotideum* C. Chr. Ind. 202. 1905; 581. 1906.

Jhelum Valley, 3500 feet, *Trotter;* Chakoti, Jhelum Valley and Titwal, Kishenganga Valley, *MacLeod.* Alt. 3000–7000 feet.

Rare in Kashmir.
Distribution: Hazara east to China and Japan, Africa.

LEUCOSTEGIA PULCHRA (Don) J. Sm. Lond. Jour. Bot. **1**: 426. 1842. *Davallia pulchra* Don, Prod. Fl. Nepal. 11. 1825.

Beddome in his Supplement, p. 13, lists *L. pulchra* for Kashmir, but I have seen no specimen. It is common from Chamba east.
Distribution: Himalaya, Ceylon, Yunnan.

MICROLEPIS WILFORDII Moore, Ind. Fil. 299. 1861.

First discovered in India by McDonell in the Buniar Nullah, near Rampur, Jhelum Valley in 1897. I found a colony on Sept. 6, 1927, below an irrigation channel, perhaps on the same spot where it was first discovered, beside the Kashmir Road at about 4500 feet (*9487*). The colony was still there when I last looked for it.
Distribution: Kashmir, Japan, China, Korea.

ATHYRIUM CRENATUM (Sommerf.) Rupr. Nyland. Spicil. Pl. Fenn. **2**: 14. 1844. *Aspidium crenatum* Sommerf. Vet. Ak. Handl. **1834**: 104. 1835.

Keran Nullah, Kishenganga Valley, in 1891, 8000 feet, *McDonell;* Below Gurais, 8000 feet, *Duthie 12,630.*

This is one of the rarest plants in the Himalaya and more material is badly needed. Hope spent a good deal of time on the question of whether it is distinct or whether it should be united with *Diplazium squamigerum.* He left the two specimens cited above in *D. squamigerum,* but his final opinion is as follows: "I have again gone over the material, and while I still think that all the Himalayan material must be identified as *A. squamigerum,* I now consider it possible that in spreading westward to Norway the Japanese plant has lost in length of sori, and become *A. crenatum.*"
Distribution: Europe, northern and temperate Asia.

ATHYRIUM ACROSTICHOIDES (Sw.) Diels in E. & P. Nat. Pfl. **1**[4]: 223. 1899. *Asplenium acrostichoides* Sw. Schrad. Jour. **1800**[2]: 54. 1801. *Asplenium thelypteroides* Michx. Fl. Bor. Am. **2**: 265. 1803. *Athyrium thelypteroides* Desv. Prodr. 266. 1827.

A very common fern, from 7000 to 10,000 feet, in damp soil.

Distribution: Himalaya, China, Russia, North America.

ATHYRIUM MCDONELLI Bedd. Handb. Suppl. 34. 1892. *Asplenium McDonelli* Bedd. Jour. Bot. **27**: 73. 1889.

Baniar-Harpat Rai Nala, 5000 feet, and Kitardaji, 6000 feet, *McDonell;* Lolab Valley, 4500–6000 feet, *MacLeod;* Kishenganga Vy., 6000 feet, *17,623.*

This species is near *A. acrostichoides*, but the lobing of the pinnae is not so regular, there is a wider sinus between the segments, which are cut down closer to the rachis, and the rhizome is distinctly though slowly creeping.

Distribution: Himalaya, China.

ATHYRIUM SETIFERUM C. Chr. Ind. Fil. 146. 1905. *Asplenium tenellum* Hope, Jour. Bombay Nat. Hist. Soc. **12**: 529. *pl. 4.* 1899; non Roxb. 1816 nec Fée, 1850–52. *Athyrium nigripes* of Bedd. Handb. 166. 1883.

Kishtwar, 14–11–1848, *T. Thomson,* cited by Hope. Alt. 4000–5000 feet.

Distribution: Northwest Himalaya.

ATHYRIUM MACKINNONI (Hope) C. Chr. Ind. Fil. 143. 1905. *Asplenium Mackinnoni* Hope, Jour. Bot. **34**: 124. 1896.

West Kashmir, 6000–10,000 feet, in 1888, *Trotter; MacLeod* in 1891; *McDonell* in 1892–3; *Duthie* in 1898. All cited by Hope. Near Keran, Kishenganga Vy., 5000–6000 feet, *17,608;* Below Kel, 6000 feet, *17,794;* Pahlgam, *8033.* The type is probably *Thomson,* Baramulla Pass, 28.8.1849. Alt. 6000–10,000 feet.

According to Hope this species includes almost all of the Himalayan specimens hitherto referred to *A. nigripes.* He does not know where to place a residue of five sheets, but states that they are not *A. nigripes.* This is a handsome fern with a pale stipe and rachis. The pinnae are attenuate at the tips and not so deeply or finely cut as in *A. pectinatum.* The stipe is long and there is an almost total absence of setae on the secondary rachises and costae.

Distribution: Trans-Indus to Sikkim.

ATHYRIUM RUPICOLA (Hope) C. Chr. Ind. Fil. 145. 1905. *Asplenium rupicola* Hope, Jour. Bombay Nat. Hist. Soc. **12**: 531. *pl. 5.* 1899.

South slope of Pir Panjal Range, 9000 feet, *Levinge* (cited by Hope); near Bagicha, Indus Valley, Baltistan, near water-fall, Aug. 1940, 8600 feet, *20,980.* Alt. 7000–12,000 feet.

Distribution: Kashmir to Kumaon.

ATHYRIUM FILIX-FEMINA (L.) Roth, Röm. Mag. **2**[1]: 106. 1799. *Polypodium Filix-femina* L. Sp. Pl. 1090. 1753.

Sarpat, 9500 feet, in 1891, *McDonell;* near Gurais and near Gulmarg, 8000–9000 feet, in 1892, *Duthie.* Cited by Hope.

Distribution: North and South America, Europe, North Africa, Asia.

ATHYRIUM FILIX-FEMINA var. DENTIGERA (Wall.) Bedd. Handb. 169. 1883. *Asplenium Filix-femina* var. *dentigera* Clarke, Trans. Linn. Soc. 11. **1**: 491. 1880. *Asplenium Filix-femina* var. *attenuata* Clarke l.c. 492. *Polypodium dentigerum* Wall. List 334, nomen. 1829.

This is one of the commonest ferns in Kashmir from 6000 to 11,000 feet. Clarke, p. 492, described a var. *attenuata* which he figured in *pl. 59, f. 1*. He collected the type north of the main valley, 10,000–12,000 feet. He admits that it comes near some forms of var. *dentigera* and Hope joined the two together as f. *dentigera* under *A. Filix-femina*.
Distribution: Kashmir to Nepal.

ATHYRIUM FILIX-FEMINA var. RETUSA (Clarke) Bedd. Handb. 170. 1883. *Asplenium Filix-femina* var. *retusa* Clarke, Trans. Linn. Soc. II. **1**: 492. 1880. *Cystopteris retusa* Dene. Jacq. Voy. Bot. **4**: 176. *pl. 177*. 1844.

Sekiwas, Upper Lidder Vy., 12,000 feet, *12,475;* Burzil Chowki to Mir Panzil Pass, ca. 12,000 feet, *19,945a*.

Distribution: Himalaya, 10,000–15,000 feet, Kashmir to Bhotan.

ATHYRIUM SCHIMPERI Moug. in Fée, Gen. Fil. 187. 1850–52. *Asplenium Schimperi* A. Br. in Schweinf. Beitr. **1**: 224. 1867. ? *Asplenium Filix-femina* var. *polyspora* Clarke, Trans. Linn. Soc. II. **1**: 493. 1880.

Basaoli, 6000 feet, *Clarke 31,595;* Rattanpir, 8000 feet, *Trotter* (cited by Hope).

This has a widely creeping rootstock and is easily distinguished. It is rare in Kashmir but becomes common farther east, especially about Mussoorie.
Distribution: Himalayas, Rajputana, Ethiopia.

ATHYRIUM FIMBRIATUM (Wall.) Moore, Ind. Fil. 185. 1860. *Aspidium fimbriatum* Wall. List 339, nomen. 1829. *Asplenium fimbriatum* Hook. Sp. Fil. **3**: 234. 1860.

Sarpat, 10,000 feet, *MacLeod* and *McDonell;* north slopes of watershed between the Jhelum and Kishenganga Valleys, never lower than 10,000 feet, *MacLeod* (cited by Hope); above Gulmarg, 9500 feet, *10,484;* Sonamarg, 10,500 feet; Pahlgam.

This is the largest of the Kashmir Athyriums and has a creeping caudex. Clarke writes that it is common from 5000 to 12,000 feet but in Kashmir it does not seem to have much altitudinal range, growing near 10,000 feet.
Distribution: Kashmir to Bhotan, Yunnan.

DIPLAZIUM POLYPODIOIDES Bl. Enum. 194. 1828. *Asplenium polypodioides* Mett. Fil. Lips. 78. 1856.

Clarke, Trotter, McDonell, cited by Hope without data. Near Kangan, Sind Valley, by spring, 6000 feet, *6924*.

One of the largest ferns in Kashmir but not so common as farther to the east. In some places the young shoots are cooked.
Distribution: North India, Malaya, Tropical Australia.

DIPLAZIUM JAPONICUM (Thunb.) Bedd. Ferns Br. Ind. Suppl. 12. 1876. *Asplenium japonicum* Thunb. Fl. Jap. 334. 1784. *Athyrium japonicum* Copeland, Bish. Mus. Bull. **93**: 43. 1932.

Keran, 5500 feet, Kishenganga Valley, *McDonell 33, 34;* Mardan Ali in 1854 (Herb. Dehra) (cited by Hope).

McDonell 34 in New York is without rhizome and suggests *Athyrium McDonelli.* The rhizome is creeping, the stipe may be longer than the rest of the leaf.

Distribution: Tropical Asia, including India, China, Japan, etc. Australia.

DIPLAZIUM SQUAMIGERUM (Mett.) Christ, Bull. Soc. Fr. **52,** Mém. 1: 51. 1905. *Asplenium squamigerum* Mett. Ann. Lugd. Bat. **2**: 239. 1866.

Sharda, Kishenganga Vy. by stream, 6000 feet, *17,751;* Below Kel, Kishenganga Valley, 6300 feet, *17,818.* Hope cites several collections of McDonell and Duthie, all apparently from the extreme west of Kashmir between 7000 and 9000 feet.

This is a very rare fern in India and suggests *Athyrium crenatum* var. *glabratum* Ching. It has a black creeping rhizome, the frond is almost tripinnate, triangular, and with the stipe is about two feet high. The scales are dark, broad, ovate-lanceolate, and the pinnules crenate. Hope considers this intermediate between typical *A. crenatum* and *Diplazium squamigerum.*

Distribution: Japan, China, North India.

ASPLENIUM VIRIDE Huds. Fl. Angl. 385. 1762.

Shish Nag, Lidder Vy., 13,000 feet, *Trotter;* Kamri Vy., 10,000–11,000 feet, *Duthie 12,552;* Gangabal Lakes, 12,000 feet, *4479;* Sonamarg, 12,000 feet, *6562;* 10,500 feet, *6869;* Baltal, 9500 feet, *7528;* Shish Nag Pass, 11,000–13,000 feet, *8407;* Near Gadsar, 11,000–12,000 feet, *18,309;* Kamri Pass, *18,712;* Minimarg, 9000–10,000 feet, *19,187.*

A fairly common rock plant at high altitudes.

Distribution: Europe, Himalaya, North America.

ASPLENIUM TRICHOMANES L. Sp. Pl. 1080. 1753.

One of the commonest ferns in Kashmir forests and found also in the inner ranges. Gilgit, Baltistan, Kamri Pass, etc., from 4000 to 12,000 feet. *21,019* was found in Baltistan between Bagicha and Olthing Thang near the Indus at 8500 feet, close to a waterfall; *17,373* in the lower Kishenganga Valley at 3000 feet, the lowest altitude at which I have found it.

Distribution: Widespread in north and south temperate regions and on tropical mountains.

ASPLENIUM SEPTENTRIONALE (L.) Hoffm. Deuts. Fl. **2**: 12. 1795. *Acrostichum septentrionale* L. Sp. Pl. 1068. 1753.

Nagmarg, 9000 feet, *Trotter;* Sonamarg, 9000 feet, *3442,* 10,000 feet, *6600;* Kishenganga Valley, 6000–8000 feet, *17,740, 17,888,* etc.

This is another common rock crevice plant. It grows in tufts and may be mistaken for a grass by the uninitiated. Usually from 6000 to 10,000 feet, but has been found up to 14,000 feet.

Distribution: Europe, North Asia, Himalaya, U. S. A.

ASPLENIUM RUTA-MURARIA L. Sp. Pl. 1081. 1753.

Sonamarg, 11,000 feet, *7192;* 9200 feet, *9865;* Taobat, Kishenganga Valley, 7500 feet, *17,865;* Badwan, Kishenganga Vy., 8000 feet, *19,599,* etc.; Kangi, Nullah, above Kangi, Ladak, 13,500 feet, *Koelz 2528;* Shingo Vy., Baltistan, 10,000–11,000 feet, *Duthie* fide Hope.

Distribution: Europe, North Asia, Himalaya, U. S. A., etc.

ASPLENIUM SEPTENTRIONALE × TRICHOMANES Murbeck, Lunds. Univ. Årsskr. **27**: 35. 1892. *Asplenium germanicum* of C. Chr. Ind. Fil. 113. 1905, non Weis. 1770.

Pahlgam, on large boulder, 7200 feet, *7883;* Kishenganga Vy., *McDonell* fide Hope; *Jerdon,* Herb. Kew, as *A. germanicum.*

One of the rarest of Kashmir plants.
Distribution: Europe, Kashmir, Hongkong.

ASPLENIUM SARELII Hook. in Blakiston, Yang-tsze 363, 364. 1862. *Asplenium pekinense* Hance, Jour. Bot. **5**: 262. 1867. *Asplenium Saulii* Baker, Syn. Fil. ed. 2. 216. 1874. *Asplenium Saulii* var. *pekinense* Bedd. Handb. Suppl. 31. 1892.

4000 feet, *Trotter 371;* Rampur to Uri, *MacLeod;* 2200 feet, *Levinge;* 3600 feet, *McDonell.* All on the Jhelum Valley Road.

A very rare fern and one of the most finely cut of the Aspleniums. In India it has only been found from Hazara to Kulu.
Distribution: Himalaya, China, Japan.

ASPLENIUM ADIANTUM-NIGRUM L. Sp. Pl. 1081. 1753.

Tangmarg, below Gulmarg, 7200 feet, *10,709;* below Titwal, 3000 feet, *17,373;* Titwal to Surkhala, 4000 feet, both in the Kishenganga Valley; below Tragbal, 7000 feet, *19,466,* etc.

Usually from 4000 to 7000 feet in comparatively dry places in the outer valleys. Much more common than *A. Sarelii.*
Distribution: Temperate Asia, Europe, Atlantic Islands, African Mts., etc.

ASPLENIUM FONTANUM (L.) Bernh. Schrad. Jour. Bot. **1799**[1]: 314. 1799. *Polypodium fontanum* L. Sp. Pl. 1089. 1753.

Sonamarg, rock crevices by the Sind River, 8000 feet, *3419;* 10,000 feet, *7229;* Lidderwat, 9000 feet, *8301;* Aru to Nafran, Lidder Vy., 9000 feet, *12,470;* Kishenganga Valley, 3000–7000 feet, *17,408; 17,456; 17,695; 17,838; 19,600;* etc. Alt. 3000–12,000 feet.

Fairly common in rock crevices.
Distribution: Western Himalayas, Europe, Central Asia.

ASPLENIUM VARIANS Wall. Hook. & Grev. Ic. Fil. *pl. 172.* 1830. *Aspidium varians* Wall. Ms. in Herb. Hook.

Pahlgam, 8000–9000 feet, *Duthie 13,466;* Sonamarg, 9200 feet, *6437;* Baltistan, near Skardu, *Thomson,* fide Hope; Near Bagicha, Baltistan, Indus Vy., 8500 feet, *21,002.* Alt. 4000–9000 feet.

Not so common in Kashmir as it becomes farther east. It is not so finely cut as *A. fontanum* and grows in humus rather than in rock crevices.
Distribution: India to China and Japan, Africa, Hawaii.

CETERACH DALHOUSIAE (Hook.) C. Chr. Ind. Fil. 170. 1905. *Asplenium alternans* Wall. List 221, nomen. 1829; Hook. Sp. Fil. **3**: 92. 1860.

Very common at lower levels on the outer ranges especially from 3000 to 7000 feet, growing on banks and walls. Alt. 3000–9000 feet.
Distribution: Himalaya, Ethiopia.

CETERACH OFFICINARUM DC. in Lam. & DC. Fl. Fr. **2**: 566. 1805. *Asplenium Ceterach* L. Sp. Pl. 1080. 1753. *Hemidictyum Ceterach* Bedd. Ferns Brit. Ind. Suppl. 13. 1876.

Mt. behind Dal Lake, 7000 feet, *3284;* Jhelum Valley Road, 4000 feet, *12,120;* Dhanni, 2800 feet, *17,366;* Dhanni to Titwal, 3500 feet, *17,372,* both in Kishenganga Valley; Gilgit, Tanner and Astor Dist, *Duthie* fide Hope. Alt. 3000–8000 feet.

Like *C. Dalhousiae* this is a xerophytic fern of the outer ranges and grows in the same sort of places. The lower surfaces of the fronds are densely covered with scales which are absent in *C. Dalhousiae.*
Distribution: Central Europe, the Mediterranean basin, Western Asia, South Africa, Western Himalaya.

WOODWARDIA RADICANS (L.) Sm. Mém. Ac. Turin **5**: 412. 1793. *Blechnum radicans* L. Mant. 307. 1771.

Basaoli, 5500 feet, *Clarke.* The only specimen reported by Hope. Alt. 3500–7500 feet.

The only place in which I have found it common in Kashmir is in the lower Kishenganga valley from Mugaffarabad to Titwal, Chenab Vy., Ramsu to Banihal. It becomes commoner as one goes east, growing in shady woods along streams. The fronds are long and arching and root from bulbils at the tips of the leaves or along the axis.
Distribution: Atlantic Islands, Mediterranean Basin, North India, South China, Java.

GYMNOPTERIS VESTITA (Wall.) Underw. Bull. Torrey Club **29**: 627. 1902. *Grammitis vestita* Wall. List 12, nomen. 1829. *Gymnogramma vestita* Pr. Tent. 218, nomen. 1836. Hook. Ic. *pl. 115.* 1837. *Syngramma vestita* Moore, Ind. Fil. 60. 1857.

I have seen no specimens from Kashmir, but since I have specimens from Hazara on the west and from various places on the east, it has most probably been overlooked. This is one of the few ferns especially sought by European visitors in the Himalayan Hill Stations. It is called mouse ear fern.
Distribution: China, North India.

CRYPTOGRAMMA STELLERI (Gmel.) Prantl, Engl. Jahrb. **3**: 414. 1882. *Pteris Stelleri Gmel. Nov. Comm. Petr.* **12**: 519. *pl. 12, f. 1.* 1768. *Pellaea gracilis* Hook. Sp. Fil. **2**: 138. *pl. 133 B.* 1858. *Pellaea Stelleri* Bak. Syn. Fil. ed. 1. 453. 1868.

Karakorum Mts., Baltistan, *Thomson;* Gurais, Kishenganga Vy., *Duthie;* Gangabal Lakes, 11,000 feet, *18,138;* Mt. Kolohoi, Upper Lidder Vy., 12,000 feet, *13,444;* Chunagund, Ladak, 9000–10,000 feet, *21,059;* Sonamarg, Tulion, Nafran, etc.

A plant of the alpine zone, usually from 9000 to 12,000 feet. One of the few ferns to cross the Himalayas into Baltistan and Ladak.
Distribution: Siberia, Himalaya, North America.

CRYPTOGRAMMA BRUNONIANA Wall. List. 396, nomen. 1829; Hook & Grev. Ic. Fil. *pl. 158.* 1829. *Cryptogramma crispa* of Bedd. Handb. 98. 1883.

Sonamarg, 11,000 feet, *6572;* above Gulmarg, 11,000 feet, *10,416;* ascent from Burzil Pass to Deosai, 13,000 feet, *19,986;* Muzaffarabad, Inayat; Marbal Pass, Clarke, etc. Alt. 10,000–15,000 feet.

Another alpine plant like the last but easily recognized by the dimorphic fronds, the fertile fronds being erect and taller.
Distribution: Himalaya, China, Japan.

CONIOGRAMME FRAXINEA (Don) Diels in E. & P. Nat. Pfl. 1[4]: 262. 1899. *Diplazium fraxinea* Don, Prodr. Fl. Nepal. 12. 1825. *Gymnogramma javanica* Blume, Enum. 112. 1828. *Syngramma fraxinea* Bedd. Handb. 386. 1883.

Jhelum Valley Road, 4500 feet, *Trotter;* Rattanpir, 7500–8000 feet, *Trotter;* Hajipir Pass, 8000 feet, *13,996;* Kishenganga Valley, 3000 feet, by dripping bank, *17,492.*

The last specimen and *Bliss 57* from the same valley approach *Coniogramme affinis* (Wall.) Hieron, the low level form farther east, as some fronds have only the lowest pinnae divided. High-level Kashmir specimens are much more compound with narrower leaflets.
Distribution: India, China, Japan, Australia, Polynesia, Tropical Africa, Madagascar.

PELLAEA HASTATA (Thunb.) Prantl, Engl. Jahrb. **3**: 418. 1882. *Pteris hastata* Thunb. Prod. Fl. Cap. 172. 1800. *Pteris calomelanos* Sw. Link. Fil. Sp. 61. 1841.

Abbottabad, Hazara, 4500 feet, 14–7–1934, *14,112.*

This fern has hitherto not been reported this far west in India. It has been reported from Simla and since it has now been found to the west of Kashmir it may be expected in the state.
Distribution: Himalaya, Hazara to Kumaon; Yunnan, Ethiopia to the Cape of Good Hope.

PELLAEA NITIDULA (Wall.) Baker, Syn. Fil. 149. 1867. *Pteris nitidula* Wall. List. 89, nomen. 1829. *Cheilanthes nitidula* Hook. Sp. Fil. **2**: 112. 1852.

Pooneh; Kishtwar, 5000 feet, *Clarke;* Chittapani Valley, 6000 feet, *Levinge;* Pir Panjal, 6000 feet, and Rattanpir, 8000 feet, *Gammie.* All cited by Hope. Alt. 3000–9000 feet.

A plant of the outer ranges. Superficially like *Cheilanthes subvillosa* but lacks the hairs.
Distribution: Afghan Frontier to Kumaon, Yunnan, West Tibet.

NOTHOLAENA MARANTAE (L.) R. Br. Prodr. Fl. N. Holl. 146. 1810; Jour. de Bot. Appl. Desv. **1**: 92. 1813. *Acrostichum Marantae* L. Sp. Pl. 1071. 1753.
Reported from Kashmir by Clarke and Beddome but without definite data. I have seen no Kashmir specimens, but since it grows near by in Kulu and Chamba, it may grow on the eastern border of the state.
Distribution: Atlantic Islands, Mediterranean Basin, Himalaya, Yunnan.

NOTHOLAENA VELLEA Ait. Jour. de Bot. Desv. Appl. **1**: 93. 1813. *Acrostichum vellea* Ait. Hort. Kew. **3**: 457. 1789.
The only Kashmir specimen I have seen was a sheet of Jerdon's at Kew marked Cashmire. It is a very rare fern in India and only three specimens are in the Dehra Herbarium and two at Gordon College, all from the Punjab Himalaya in the vicinity of Pangi, Kulu, and Chamba.
Distribution: Atlantic Islands and Mediterranean Basin to Afghanistan and the Northwest Himalaya.

CHEILANTHES PTERIDIOIDES (Reich.) C. Chr. Ind. Fil. 178. 1905. *Polypodium pteridioides* Reich. L. Syst. Pl. ed. novis. **4**: 424. 1780. *Polypodium fragrans* L. Mant. 307. 1771, non 1753. *Cheilanthes fragrans* Webb & Berth. Hist. Nat. Canar. **3**[2] (3) : 452. 1847.

Jhelum Valley, near Pirni, 5000–6000 feet, *Duthie;* Kishtwar, 3500–5000 feet, *Clarke;* both cited by Hope; Domel, Jhelum Valley Road, 2500 feet, *11,100;* Kishenganga Valley, 3500–6000 feet, *17,413; 17,436; 17,550.*

This is one of the most xerophytic of Kashmir ferns and grows in the drier outer ranges. At Titwal, Kishenganga Valley, it grew in the crevices of the walls of terraced fields near *Asplenium Adiantum-nigrum, Ceterach Dalhousiae,* and *Ceterach officinarum.*
Distribution: Atlantic Islands, Mediterranean Basin, Northwest Himalaya.

CHEILANTHES PERSICA (Bory) Mett. Kuhn, Fil. Afr. 73. 1868. *Nothoiaena persica* Bory, Bél. Voy. Bot. **2**: 23. 1833. *Cheilanthes Szovitzii* Fisch. & Mey. Bull. Soc. Mosc. **6**: 260, nomen. 1833; 241. 1838.

Skardu, Baltistan, 8000 feet, *20,428;* Kiris, Indus Valley Baltistan, 8000 feet, *20,891;* Takht, Srinagar, 6000 feet, *9465;* Rampur, Jhelum Valley, 4000 feet, *12,128;* Martand, Kashmir, 5200 feet, McDonell; Kishtwar, *Clarke.*

This is a fern from the Mediterranean flora which penetrates deep into the Himalayas as far as Gilgit and Baltistan. It is one of the few ferns able to live in the low hills of the north Punjab and Northwest Frontier Province. The species is easily separated from the last by the abundant red woolly hairs from the sori which cover the lower surfaces of the pinnules.
Distribution: Mediterranean Basin to the Northwest Himalaya.

CHEILANTHES SUBVILLOSA Hook. Sp. Fil. **2**: 87. *pl. 98B.* 1852.

Chittapani Valley, 9000 feet, and Rattan Pir, 8000 feet, *Trotter.* Alt. 7000–10,000 feet.

Few specimens from Kashmir are in collections. It should be looked for on the southern slopes of the Pir Panjal Range. It can easily be separated from *Pellaea nitidula,* which it resembles, by the hairs on the lower surface of the veins.
Distribution: Northwest Himalaya from Hazara to Sikkim.

CHEILANTHES ALBOMARGINATA Clarke, Trans. Linn. Soc. II. **1**: 456. *pl. 52.* 1880. *Cheilanthes farinosa* var. *albomarginata* Bedd. Handb. Suppl. 22. 1892.

Although this is a very common fern east of Kashmir the only one who seems to have found it within the state was Clarke, who found it at Basaoli at 5000 feet.
Distribution: Himalaya, South India.

CHEILANTHES DALHOUSIAE Hook. Sp. Fil. **2**: 80. *pl. 78B.* 1852. *Cheilanthes farinosa* var. *Dalhousiae* Bedd. Handb. 93. 1883.

Clarke reports this from Kashmir but without data and Hope does not mention any Kashmir specimens. I have only found it near the Indus River in the vicinity of Bagicha, Baltistan, at about 8500 feet, *20,961* and *21,003* in Aug. 1940.

Although this plant has been referred to *C. farinosa* it is without white powder at all stages. The involucres are deeply crenulate, toothed or lacerate.
Distribution: Himalaya, Hazara to Sikkim.

CHEILANTHES FARINOSA (Forsk.) Kaulf. Enum. 212. 1824. *Pteris farinosa* Forsk. Fl. Aegypt.-Arab. 187. 1775.

Jhelum Valley, between Domel and Chakota, *MacLeod;* Kaman Goshi, 3000 feet and Tawi Valley, 4000 feet, *Gammie,* the only specimens reported by Hope.

I found this near Domel at 2000 feet in Aug. 1931. It becomes common east of Kashmir and as it is not rare in Abbottabad, Hazara and grows in Rawalpindi Dist. it probably grows on the south slopes of the Pir Panjal Range.
Distribution: India, China, Japan, Africa, Tropical America, Fiji.

ONYCHIUM LUCIDUM (Don) Spr. Syst. **4**: 66. 1827. *Leptostegia lucida* Don. Prodr. Fl. Nepal 14. 1825. *Onychium contiguum* Hope, Jour. Bombay Nat. Hist. Soc. **13**: 444. 1901. *Onychium japonicum* var. *multisecta* F. Henderson ex Clarke, Trans. Linn. Soc. II. **1**: 459. 1880. *Onychium japonicum* var. *lucidum* Christ.

Rattan Pir, 8000 feet, *Trotter;* Pir Panjal, 8000 feet, *Gammie;* cited by Hope; Aliabad Pass, Pir Panjal Range, 7000–8000 feet, *13,991.* I have also found it on the Batot Pass at about 6000 feet.

Distribution: North India, China.

ADIANTUM CAUDATUM L. Mant. 308. 1771.

This is perhaps the commonest fern in the foothill zone of the Northwest Himalaya and begins at the edge of the plains and ascends to about 5000 feet, rarely to 6000 feet. It penetrates into Kashmir by the Jhelum Valley and the Tawi Valley of Jumu. It is no doubt common in Poonch and the outer spurs of the Pir Panjal Range but I have seen no specimens. It roots freely at the tips.

ADIANTUM CAPILLUS-VENERIS L. Sp. Pl. 1096. 1753.

One of the commonest ferns in North India and one of the two or three ferns which are found in the plains of the Punjab. It is common in wells and wet banks in the plains and in the hills it frequents waterfalls and springs. It occasionally penetrates deep into the Himalayas. I found one poor specimen in Baltistan, and *Koelz 2821* was collected at 12,500 feet in the Kangi Nullah, Ladak.
Distribution: Europe, Africa, temperate Asia, Polynesia, Central America, etc.

ADIANTUM VENUSTUM Don, Prodr. Fl. Nepal 17. 1825.

This is probably the commonest forest fern between 6000 and 9000 feet and it may be found from 4000 to 12,000 feet.
Distribution: Afganistan, North India.

ADIANTUM PEDATUM L. Sp. Pl. 1095. 1753.

Ashdari, Padar, Kishtwar, 8000 feet, *2901;* Tragbal, 9000 feet; Aru, Lidder Valley, 8500 feet; Sharda to Kel, Kishenganga Valley, 6500 feet, *17,803;* Gulmarg, 8500 feet, *Martin.* Alt. 6500–10,000 feet.

Not rare; but the "stag-horn fern" is not found every day. It needs deeper shade and richer, damper humus than is required by *A. venustum*.
Distribution: Japan, China, Japan, North America.

PTERIS VITTATA L. Sp. Pl. 1074. 1753. *Pteris longifolia* L. and many authors, in part.

One of the commonest ferns in the foothill zone and up to 5000 feet in the outer hills. Found even in the plains by running water; and the commonest potted fern in the Punjab. This fern has usually been called *P. longifolia* in India, but according to Carl Christensen this name belongs to a tropical American fern.
Distribution: More tropical parts of Europe, Africa, Asia, Australia, and Polynesia.

PTERIS QUADRIAURITA Retz. Obs. **6**: 38. 1791. *Pteris biaurita* var. *quadriaurita* C. Chr. Ind. Fil. 605. 1906.

Rattanpir, 7500–8000 feet, *Trotter*.

This fern becomes very common farther east.
Distribution: India, Ceylon.

PTERIS CRETICA L. Mant. 130. 1767.

This is another very common fern in the drier, outer ranges at altitudes of from 3000 to 7000 feet. The difference between the fertile and sterile fronds is striking. The pinnae of the sterile fronds are wider and have spinulose margins.
Distribution: Atlantic Islands and Mediterranean Basin to the Philippines and New Zealand; West Indies, Brazil, etc.

PTERIS EXCELSA Gaud. Freyc. Voy. Bot. 388. 1827.

The only Kashmir record is a doubtful one. Hope states that a sterile specimen of Gammie's from Rattanpir referred to *P. quadriaurita* might be a sterile specimen of *P. excelsa*. Since *Inayat 20,432* from the Siran Valley, Hazara, comes from west of Kashmir, and this is a common fern eastward, it is most probable that it will be found on the Pir Panjal Range.
Distribution: North India and Malaya to Fiji and Hawaii.

PTERIDIUM AQUILINUM (L.) Kuhn; v. Deck. Reisen **3**[3]: Bot. 11. 1879. *Pteris aquilina* L. Sp. Pl. 1075. 1753.

Common on sunny grassy hillsides or forest openings from about 6000 to 9000 feet. In the Kishenganga Valley it begins as low as 3000 feet in grassy openings in the *Pinus longifolia* forest and continues in suitable places to above 9000 feet on the Kamri, Burzil, and Rajdhiangan Passes, where it enters the *Artemisia maritima* zone. It may grow to be six feet tall.

Tryon (Rhodora **43**: 22. 1941) refers the Indian material to var. *Wightianum* (Ag.) Tryon. He cites my *4761* and *6492* as being more glabrous than most specimens of the variety.
Distribution: Temperate and tropical regions of the world.

POLYPODIUM MICRORHIZOMA Clarke, Baker Syn. Fil. 511. 1874. *Goniophlebium microrhizoma* Bedd. Ferns Brit. Ind. Suppl. 21. *pl. 384*. 1876.

Beddome in his handbook gives the distribution "Kashmir to Bhotan." I have collected it in Dalhousie a few miles to the east but have seen no Kashmir specimens.
Distribution: Himalaya, Yunnan.

POLYPODIUM LACHNOPUS Wall. List 310, nomen. 1829; Hook. Ic. *pl. 952.* 1854. *Goniophlebium lachnopus* J. Sm. Hook. Gen. Fil. ad *pl. 51.* 1840.

Clark and Beddome both mention this as a Kashmir plant but I cannot find any specimens. I have many specimens but the nearest are from Simla and Kulu. This fern is often mixed with the last but can be recognized by the abundant, dark, long pointed ramentae clothing the creeping rhizome. Both this and the last are usually epiphytes.
Distribution: Himalaya.

POLYPODIUM ARGUTUM Wall. List 308, nomen. 1829; Hook. Sp. Fil. **5**: 32. 1863. *Goniophlebium argutum* Hook. Gen. Fil. ad *pl. 51.* 1840.

This is another epiphyte which according to Beddome in his Handbook, p. 324, grows from Kashmir to Bhotan. I have seen no specimens.
Distribution: Simla Hills to Sikkim.

POLYPODIUM MEMBRANACEUM Don, Prodr. Fl. Nepal 2. 1825. *Pleopeltis membranacea* Moore, Ind. Fil. 191. 1860.

Jumu, Tawi Valley, 4000–5000 feet, *Trotter; Gammie*, 4000 feet.

Like the three previous ferns this becomes common as soon as the monsoon is sufficient to make epiphytes possible.
Distribution: Eastern Kashmir to the Philippines, and Celebes, Ceylon.

POLYPODIUM STRACHEYI (Ching) C. Chr. Ind. Fil. Suppl. **3**: 159. 1934. *Phymatodes Stracheyi* Ching, Contr. Inst. Bot. Nat. Acad. Peiping **2**: 83. 1933. *Polypodium Stewartii* Clarke, Trans. Linn. Soc. II. **1**: 563. 1880; non *Pleopeltis Stewartii* Bedd. 1867.

Pahlgam in rock crevices, 10,000 feet, Aug. 8, 1927, *9276.*

New to Kashmir. Previously the westernmost station of this plant was the Sach Pass in Chamba.

POLYPODIUM LORIFORME Wall. List 271, nomen. 1829; Mett. Abf. Senckenb. Ges. Frankfurt **2**: 92. *pl. 1. f. 50.* 1857. *Polypodium lineare* var. *steniste* Clarke, Trans. Linn. Soc. II. **1**: 559. 1880. *Polypodium lineare* var. *loriforme* Takeda, Notes Bot. Gard. Edinb. **8**: 272. 1915. ? *Lepisorus loriformis* Ching, Bull. Fan. Mem. Inst. **4**: 81. 1933.

Liddarwat, 9000 feet, *8278;* Pahlgam, *8323*; Ferozepur Nullah, near Gulmarg, 7500 feet, Sonamarg, *13,453.*

I have puzzled over these specimens; *8323* may be different. In it the lower side of the frond is completely covered by the large sori. This is not the case in the other specimens but it may be a matter of age. The leaves are thicker than those of *P. clathratum* and when dry the veins are still invisible. The leaves of *P. clathratum* seem thin when dried, they are greener in color, and the veins are visible, though the freshly picked fronds are fairly thick and take a long time to dry. *P. excavatum* Bory, with which it

has sometimes been confused, is thin-leaved even when fresh and dries quickly. It is usually an epiphyte and I have not found it in Kashmir. Clarke does not mention clathrate scales in *P. loriforme*, but they are present. I suspect that the Chinese and Japanese material of Ching and Takeda may be different.
Distribution: North India, South China?

POLYPODIUM CLATHRATUM Clarke, Trans. Linn. Soc. II. **1**: 559. *pl. 82. f. 1.* 1880. *Pleopeltis clathrata* Bedd. Handb. 348. 1883.

Pahlgam, *5950;* Lidderwat, above Pahlgam 9000 feet, *8253;* Sonamarg, 9500 feet; 10,000 feet, *13,455;* Aru to Nafran, Lidder Valley, 9000 feet, *12,469;* Nittar Valley, Gilgit Dist, in 1892, *Duthie.* Alt. 9000–12,000 feet.

This is a fairly common rock plant at high levels in Kashmir in the shade of forest trees. The clathrate scales remain on the rhizome after they have fallen from the old sori. The leaves dry very slowly. They are usually much narrower and somewhat shorter in length than in *P. excavatum* which it sometimes resembles superficially. *P. excavatum* is usually an epiphyte and the leaves die at the close of the monsoon, while *P. clathratum* has evergreen leaves, like *P. loriforme.*
Distribution: North India, North China. Afghanistan.

CYCLOPHORUS POROSUS (Wall.) Pr. Epim. 130. 1849. *Polypodium porosus* Wall. List 266, nomen. 1829; Mett. Pol. 128. n. 259. 1857. *Niphobolus porosus* Br. Tent. 202. 1836. *Niphobolus fissus* of Bedd. Ferns Brit. Ind. Correct. 2. 1870.

"From Kashmir to Bhotan, very common." Clarke. In my experience this fern grows from Kulu and Chamba eastward and I have seen no Kashmir specimens. Some botanists use the name *Pyrrosia* for this genus.
Distribution: North India, China.

SCHIZAEACEAE

LYGODIUM JAPONICUM (Thunb.) Sw. Schrad. Jour. **1800**[2]: 106. 1801. *Ophioglossum japonicum* Thunb. Fl. Jap. 328. 1784.

"Near Domel, Jhelum Valley, in great profusion," *MacLeod;* Pooneh Valley, 3000 feet, *Winterbottom;* Tawi Valley, 3500 feet, *Gammie.* Alt. 2500–5000 feet.

Apparently very local. I have found it at Mansera in Hazara and in Chamba but the only *Lygodium* I have found in Kashmir was a sterile plant from Ramban on the Jumu to Srinagar Road.
Distribution: India, China, Japan; tropical Asia and Australia.

OSMUNDACEAE

OSMUNDA CLAYTONIANA L. Sp. Pl. 1066. 1753.

Common in large patches on open hillsides and in open places in the forest from 8000 to 11,000 feet. Has been reported at 6000 feet.
Distribution: Himalaya, China, North America.

SALVINIACEAE

SALVINIA NATANS (L.) All. Fl. Pedem. **2**: 289. 1785. *Marsilia natans* L. Sp. Pl. 1099. 1753.

Very common in the lakes and canals in the Valley of Kashmir at about 5000 feet.
Distribution: India, Central China, Europe.

MARSILIACEAE

MARSILIA MINUTA L. Mant. 308. 1771 (excluding β). *Marsilia erosa* Willd. Sp. Pl. **5**: 540. 1810.

Very common in rice fields and shallow water from the plains to about 6000 feet. The leaves which form in a dry period are smaller and are often erose at the tip.
Distribution: India, Java, Philippines.

OPHIOGLOSSACEAE

OPHIOGLOSSUM VULGATUM L. Sp. Pl. 1062. 1753.

Cited for Kashmir by Clausen, Mem. Torrey Club **19**: 127. 1938.

I have an *Ophioglossum* from Pahlgam, in grass, 7500 feet, which probably belongs here.
Distribution: North America; Europe to India, Japan, Kamtchatka.

BOTRYCHIUM LUNARIA (L.) Sw. Schrad. Jour. **1800**[2]: 110. 1801. *Osmunda lunaria* L. Sp. Pl. 1064. 1753.

Western Tibet, Falconer and Karakorum Mts., *Clarke*, cited by Clarke; Mt. Apharwat, above Gulmarg, 11,000 feet, in rocks, *8587*; Pahlgam, in forest, 7500 feet, *9232*.

Distribution: Colder portions of both northern and southern hemispheres.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Schrad. Jour. **1800**[2]: 111. 1801. *Osmunda virginiana* L. Sp. Pl. 1064. 1753.

Lolab Valley, *R. C. Wroughton*, U. S. Nat. Herb. cited by Clausen; Canon Stokoe, Chaplain of Srinagar, has a specimen from Pahlgam, Lidder Valley. Hope states that *Inayat 20,388* from the Kaghan Valley, Hazara is typical *B. virginianum*.

There has been a great deal of discussion about the presence or absence of *B. virginianum* in India. Clarke maintained that there was only one species and he called it *B. virginianum*. Beddome in his Handbook, p. 471, mentions only one form which he calls *B. virginianum* var. *lanuginosum*. Probably Clarke had only *B. lanuginosum*, which is the common Himalayan plant east of Kashmir. The only note I have of the presence of *B. virginianum* east of Kashmir is the statement of Trotter that McDonell found it in Chamba. Clausen places the Kashmir specimen in subsp. *typicum*.
Distribution: North America, Europe, India, China, Japan.

EQUISETACEAE

EQUISETUM ARVENSE L. Sp. Pl. 1516. 1753.

Very common in Kashmir. In the Kishenganga Valley I have seen the young fertile stems push up as soon as the snow melted. It is found at Ganderbal in the main valley and penetrates to Dras and Ladak. Alt. 5000–12,000 feet.
Distribution: North America, Europe, North and Central Asia.

EQUISETUM DEBILE Roxb. Vauch. Monog. Prel. 376. 1822.

Srinagar, 5200 feet, *13,458*; below Sharda, Kishenganga Valley, in sand, 6000 feet. *17,730*; Rupal Nullah, Astor Dist., 8000 feet, *18,884* (possibly *E. ramosissimum*).

Distribution: India, Ceylon, Malaya, Polynesia.

EQUISETUM RAMOSISSIMUM Desf. Fl. Atlant. **2**: 398.

Very common, penetrating into the inner valleys of Ladak and Baltistan. It is found from the plains to 9000 feet. Not very different from *E. debile* but more scabrous, the cones usually single, not approximated, the secondary cones more nearly sessile and the basal branches from the main stem ascending rather than at right angles to it.

Distribution: Widespread in the northern hemisphere.

LYCOPODIACEAE

LYCOPODIUM SELAGO L. Sp. Pl. 1102. 1753.

Sonamarg, 13,000 feet, among dwarf rhododendrons, *7336* (f. *angustinum* Christ, det. Nessel); above Gulmarg, 12,000–13,000 feet, *8609;* Burzil, 10,000 feet, *Koelz 9410;* Gilgit, 12,000 feet, *Duthie?*

Distribution: North America, Europe, North Asia.

SELAGINELLACEAE

SELAGINELLA SANGUINOLENTA (L.) Spring, Monog. Lycopod. **2**: 57. 1849. *Lycopodium sanguinolentum* L. Sp. Pl. 1104. 1753.

Sonamarg, 8–8–1928, 10,000 feet, *9458*, det. Alston.

Distribution: North India.

SELAGINELLA JACQUEMONTII Spring, Monog. Lycopod. **2**: 194. 1849.

In determining *6660*, *7173*, and *7368*, Alston refers this species to *L. sanguinolenta* as a variety. Baker and Hieronymus, on the other hand, in their monographs made *S. Jacquemontii* a synonym of *S. borealis* Spring. The species or variety is common in the Kishenganga Valley on cliffs from 3000 to about 8000 feet, *17,381*, *17,458*, *17,833*, *17,888a*, and *17,878* all seem to belong here.

Distribution: North India.

SELAGINELLA AITCHISONI Hieron. in E. & P. Nat. Pfl. **1**[4]: 674. 1901.

Pahlgam, *5959;* Sonamarg, *6791;* Baltal, *7464*. Alt. 7000–11,000 feet.

All det. by Alston. He refers this form to *S. sanguinolenta* as a variety and the new combination will probably be published in his monograph in due course.

Distribution: North India.

REJECTED SPECIES

DRYOPTERIS BRUNNEA (Wall.) C. Chr. Ind. 255. 1905. *Polypodium brunnea* Wall. List 333, nomen. 1829. *Phegopteris distans* Mett. Pheg. Asp. 16 n. 23. 1858. *Polypodium distans* Don. Prodr. Fl. Nepal 2. 1925.

Specimens referred to this are probably *D. laterepens.*

DIPLAZIUM MAXIMUM (Don) C. Chr. Ind. Fil. 235. 1905. *Asplenium maximum* Don, Prodr. Fl. Nepal 8. 1825. *Asplenium latifolium* Don, Prodr. Fl. Nepal 8. 1825. *Athyrium maximum* Copel. Bish. Mus. Bull. 59, 54. 1929.

Clarke reports this fern from Kashmir under the name of *Asplenium latifolium.* He gives no data and I do not think that it grows in the state. Hope thought that he had *Diplazium polypodioides,* to which this is related.

Distribution: Tropical Asia, Polynesia, Australia.

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(exclusive of fungi)

(See also under Morphology: **Castellanos; Occhioni**)

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